

LESLIE

ORGAN SPEAKER

PIPE VOICE OF THE ELECTRIC ORGAN

MODEL 22H

MODEL 22R

for the

HAMMOND
ORGAN

OWNER'S MANUAL

INSTRUCTIONS, SERVICE INFORMATION
AND PARTS LIST

ELECTRO
PASADENA



MUSIC
CALIFORNIA

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THE LESLIE SPEAKER

Models 22H & 22R

The Models 22H and 22R Leslie Speakers are expressly designed for use with the Hammond Organ. Functionally the two cabinets, as shipped from the Electro Music factory, are identical. However, the 22R has been prepared for easy installation of the spinet-type Hammond reverberation kit. Procedures for connecting the Leslie Speaker will vary according to the model Hammond Organ which is involved. Detailed installation information is contained in this manual.

The Leslie Speaker is highly efficient since it has been created exclusively for organ usage. Broad frequency response is obtained as the result of the separate handling which is given to upper and lower frequencies. The unique tremulant produced by the Leslie Speaker is the result of moving elements, which, by creating a fully realistic tremulant, bring to the organ a type of sound which is truly characteristic of the pipe organ. Tremulant is controlled in the Leslie Speaker simply by turning these moving elements on or off.

The Leslie Speaker may be used on Hammond two-manual models which are equipped with built-in speaker systems, as well as on models without built-in speaker systems. With the former models a speaker selector switch ("Echo") is used to enable the organist to use the Leslie Speaker and the organ's built-in speaker system either separately or together. An Echo switch is also used with the larger Hammond consoles — those without built-in speaker systems — in installations employing two or more speaker units.

Complete instructions, for a variety of Leslie Speaker installations, and for all two-manual Hammond Organ models, are given in detail in this owner's manual.

SPECIFICATIONS

Cabinet: Selected hardwood veneers with quality lacquer finish to blend with consoles.

Dimensions: 29" wide, 20½" deep, 41" high.

Speakers: Treble—compression-type driver, permanent magnet, 16 ohms impedance.

Bass —15-inch heavy duty, permanent magnet, 16 ohms impedance.

Amplifier: 40 watts output.

Power Supply: 117 Volt, 60 Cycle.

Power Consumption: 2.1 Amps, 190 Watts.

Weight—22H: 135 pounds net

152 pounds, boxed for shipment

22R: 138 pounds net

155 pounds, boxed for shipment

PREPARING THE SPEAKER FOR USE

After unboxing the Leslie Speaker:

1. Remove the upper and lower compartment back covers; take out the box in the upper compartment containing the 428 Tremolo Control, the B+ Adapter, and the lubricating oil. If cabinet is a 22R, also remove the kit of materials for installing reverberation unit.
2. Remove the wood shipping blocks from the upper and lower motors and from the amplifier, so that these units may float freely on their rubber mountings. Save the wood blocks for possible future use in shipping the cabinet. Also remove the rubber bands, and in the case of the 22R, the tape used to hold the upper rotor in position during shipment.
3. Make sure the upper belt is in place on the rotor, idler, and motor pulleys.

4. Select the groove on the upper motor pulley which provides the desired tremolo speed. The center groove is the one used most often; faster or slower speeds may be obtained by use of the other pulley grooves.
5. Replace the upper and lower compartment back covers.
6. Remove shipping skid and place the cabinet so it rests solidly on the floor. If floor is uneven use snug-fitting wedges to keep cabinet from rocking.
7. Plug the speaker connecting cable into the Leslie amplifier. This may be either the 5-conductor cable (with 6-pole plug) as supplied by Hammond, or the 6-conductor cable which is obtainable as an accessory from Electro Music.

Note: Complete preparation of the 22R Leslie Speaker may involve installation of the reverberation kit. To make this installation, follow the instructions given on page 7.

INSTALLATIONS USING A SINGLE LESLIE SPEAKER

Those installations using a single Leslie Speaker are the most common, hence will be discussed first in this manual. Installations using several Leslies, or combinations of Leslie Speakers and Hammond tone cabinets will be explained in subsequent pages. The method for connecting a single Leslie Speaker will vary according to the model Hammond Organ which is being used. Complete details will be found in the following several sections of this manual.

Connecting the Model 22H or 22R to the Hammond Spinet, Models L-100, M-1, M-2, M-3, or M-100

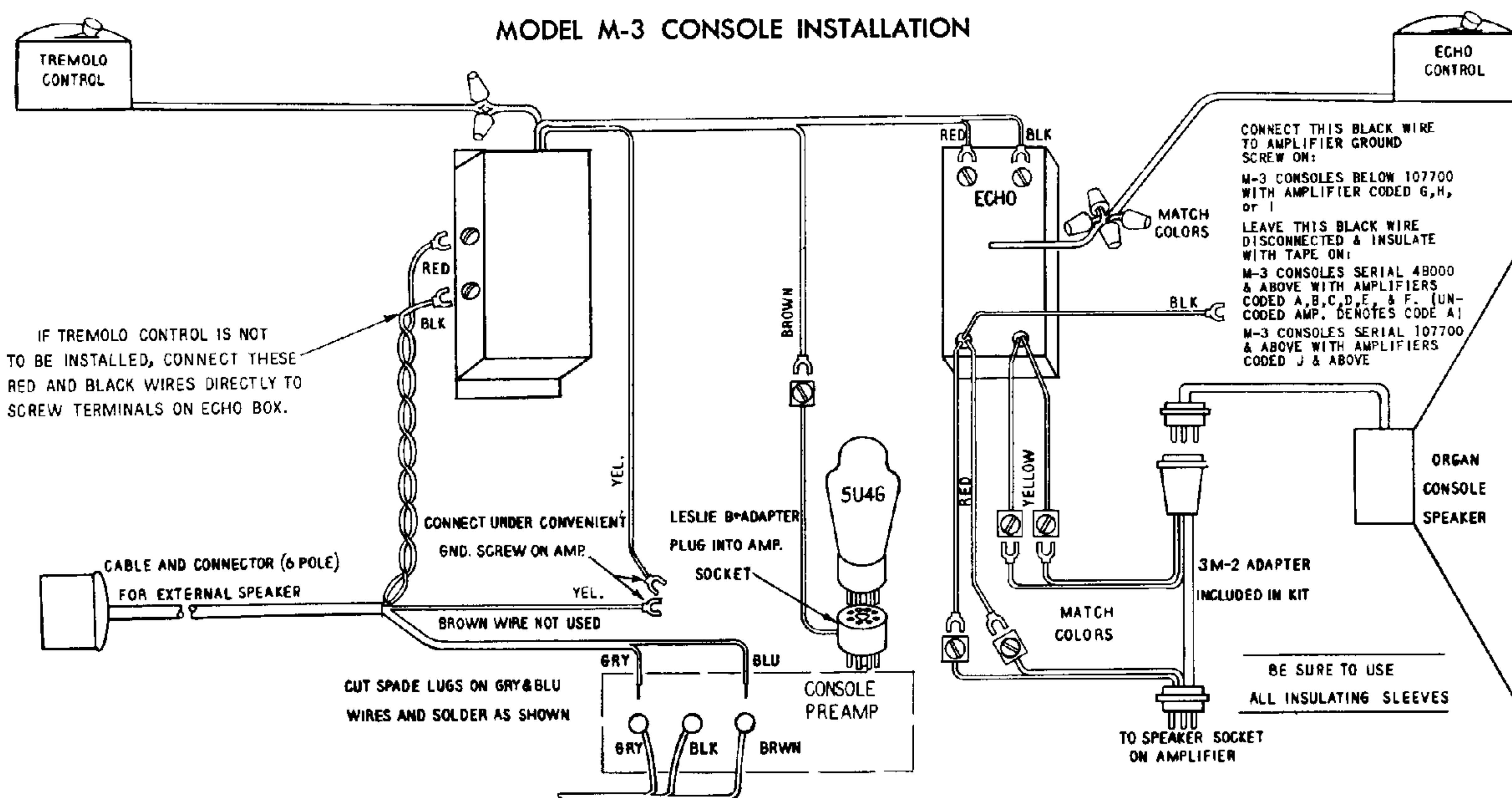
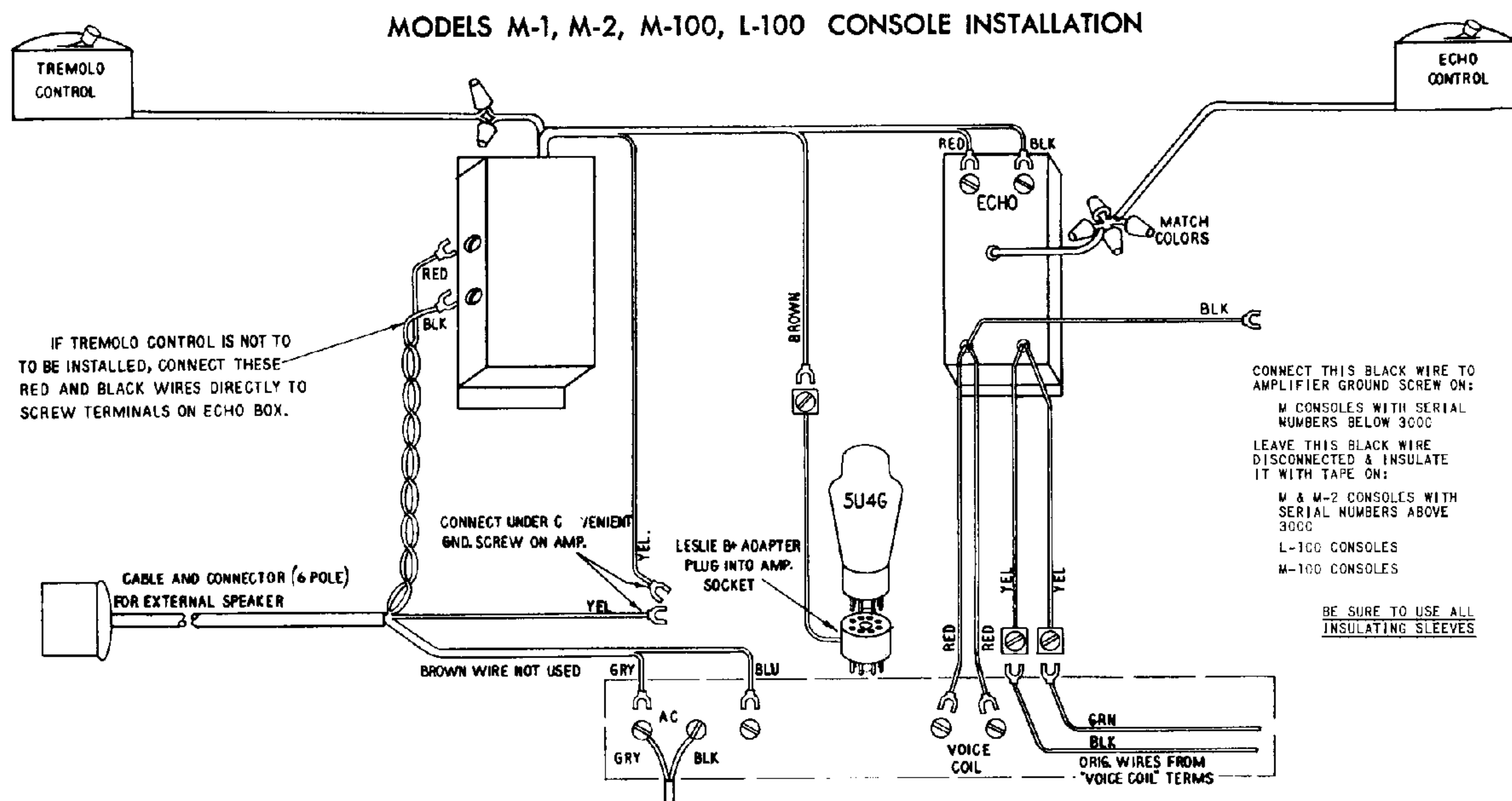
When the Leslie Speaker is to be connected to any of the Hammond Spinet model organs, the Leslie 3-M Echo Control Kit should be used. This kit contains the needed connecting cable — in this case a 30-foot length of cable with appropriate connectors installed at both ends. Also included in the kit is the switch with associated equipment for the Echo Control, a device that permits the organist to use either the Leslie or the console speaker, or to use both speakers at the same time. A 428 Tremolo Control, furnished with the speaker, provides the means for turning the Leslie tremolo on and off.

Installation should be made as follows:

1. Attach the tremolo and echo control cases to the wood rail directly in front of the lower manual by choosing the two mounting holes in each control case which best center the wood screws in the rail. Use the screws which are provided. Controls may be located together at either end, or with one at each end of the rail.
2. Pass the control cables into the interior of the console in one of the following ways:
 - a. Push the cables through the felt dust seal found underneath the manuals just above the knee panel. (Use a small screwdriver to push the felt down to create an opening near the left end of this seal.) Push the cables through this opening.
 - b. Run the cables down along the corner where the knee panel and the end of the console join, then underneath to the back of the console. Bring the cables into the console from the rear.
3. Mount the tremolo and echo terminal boxes inside the console at a convenient point, making sure that the connecting and control cables will reach. Fasten the boxes in place using the wood screws which are provided.

4. Connect the wiring exactly as shown in the following diagrams. NOTE: In using the wire nuts be sure to hold the wire ends parallel and together, but do not twist them. Insert these ends into the opening of the nut, pushing firmly and turning nut in a clockwise direction until the connection is made secure.

5. Secure the external speaker cable at the lower right (treble) corner of the console, using the clamp which is supplied. When all the indicated connections have been made, the installation is complete except for possible regulation of the volume setting. This should be done, as needed, according to the instruction given on page 5.



Connecting the Model 22H or 22R Leslie Speaker to the Hammond Model A-100 Organ

When the Leslie Speaker is to be connected to the Hammond Model A-100 Organ, the Leslie A-100 Echo Control Kit should be used. The kit contains the required connecting cable assembly as well as the 3H Echo Control. This control enables the organist to channel the organ's output to the Leslie Speaker, to the console speaker, or to both speaker systems at the same time. A 428 Tremolo Control, furnished with the speaker, provides the means for turning the Leslie tremolo on and off.

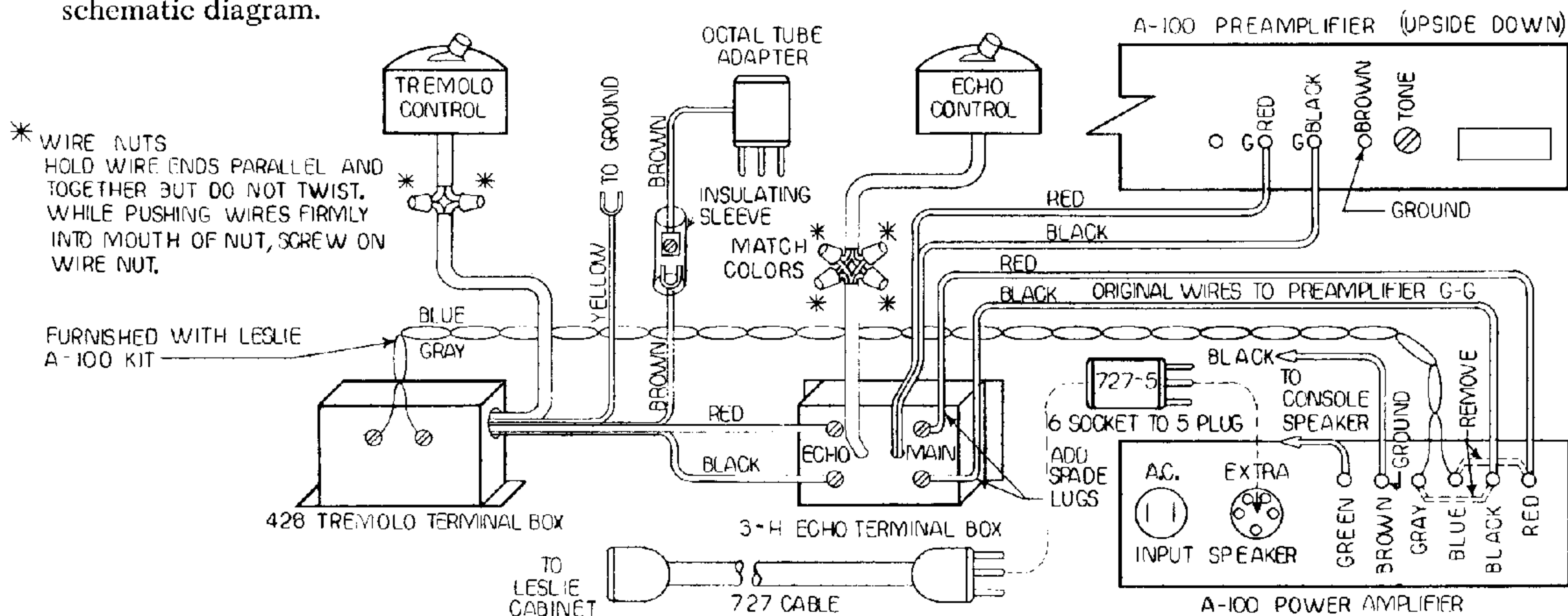
The Leslie Speaker is connected to the Hammond Model A-100 Organ by following the steps described below:

1. Attach the tremolo and echo control cases to the wood rail directly in front of the lower manual by choosing the two mounting holes in each control case which best center the wood screws in the rail. Use the screws which are provided. Controls may be located together at either end, or with one at each end of the rail.
2. Pass the control cables into the interior of the console in one of the following ways:
 - a. Push the cables through the felt dust seal found underneath the manuals just above the knee panel. (Use a small screwdriver to push the felt down to create an opening near the left end of this seal.) Push the cables through this opening into the generator compartment, then reach behind the starting motor and pull the cables through.
 - b. Run the cables down along the corner where the knee panel and the end of the console are joined, then underneath toward the back of the console. Remove the back of the console and cut a small notch in the bottom shelf to provide access for the cables to the interior of the console.
3. Mount the tremolo and echo terminal boxes inside the console at a convenient point, making sure that the connecting and control cables will reach. Fasten the boxes in place using the wood screws which are provided.
4. Remove the jumper wires between the gray and black terminals and between the blue and red terminals on the console amplifier. These jumper wires are inside the amplifier, as indicated in the schematic diagram.
5. Remove the red and black wires from the console pre-amplifier "G-G" terminals which are located near the tone control. Attach these two wires to the "Main" terminals on the 3H Echo terminal box, using the spade lugs which are provided.
6. Attach the red and black wires from the 3H Echo terminal box to the "G-G" terminals just vacated.
7. Attach the 4-wire echo control cable to the 4-wire cable from the 3H Echo terminal box, matching all the colors, and using the wire nuts which are provided. NOTE: In using the wire nuts, be sure to hold the wire ends parallel and together, but do not twist them. Insert these ends into the opening of the nut, pushing firmly and turning nut in a clockwise direction until the connection is made secure.
8. Attach the wires from the 428 Tremolo terminal box:

Red and Black wires to the "echo" terminals on the 3H Echo terminal box.

Brown wire to the brown wire on the octal tube adapter, using the spade lug connection, and pushing the insulating sleeve over the terminal after the connection has been made.

Yellow wire to a convenient ground connection.
9. Remove the 5U4-GB tube from the console amplifier, then insert the octal tube adapter into the vacated socket. Finally, insert the 5U4-GB tube into the adapter.
10. Using the blue and gray wires which are furnished, make a connection between the terminals of the 428 Tremolo terminal box, and the blue and gray terminals on the console amplifier.
11. Attach the 2-wire tremolo cable to the 2-wire cable from the 428 Tremolo terminal box, using the wire nuts which are provided. Be sure to follow the previously explained procedure in using the wire nuts.
12. Insert the plug of the 727-5 Adapter into the extra speaker socket on the A-100 Amplifier, then insert the connecting cable plug into the adapter. The receptacle at the opposite end of the cable is to be connected to the amplifier in the Leslie Speaker. The installation is now complete except for the regulation of the volume, as may be required. The volume control should be set according to detailed instructions on page 5.



Connecting the Model 22H or 22R Leslie Speaker to Hammond Models Without Self-contained Speakers

For Hammond Models A, B, C, D, E, BV, CV, B-2, C-2, RT-2, B-3, C-3, RT-3, the connection is made between the organ console and the Leslie Speaker by means of the regular connecting cable which is furnished with the Hammond console. A 428 Tremolo Control, furnished with the speaker, provides the means for turning the Leslie tremolo on and off.

The Leslie Speaker is connected to any of the above-named Hammond models by use of the following procedures:

1. Attach the tremolo control case to the wood rail in front of the lower manual, choosing the two mounting holes in the case which best center the wood screws in the rail. Use the screws which are provided. The Tremolo Control may be located at either end, although the location at the left end, directly in front of the pre-set keys, is generally preferred.
2. Pass the control cable into the interior of the console in one of the following ways:
 - a. Push the cable through the felt dust seal found underneath the manuals just above the knee panel. (Use a small screwdriver to push the felt down in order to create an opening near the left end of this seal.) Push the cable through this opening into the generator compartment, then reach behind the starting motor and pull the cable through.
 - b. Run the cable down along the corner where the knee panel and the end of the console are joined, then underneath toward the back of the console. Remove the back of the console, and cut a small notch in the bottom shelf to provide access for the cable to the interior of the console.
3. Mount the tremolo terminal box inside the organ console at a convenient point, making sure that the connecting and control cables will reach. Fasten the box in place using the wood screws which are provided.
4. Connect the two-wire cable from the tremolo control to the two-wire cable from the tremolo terminal box, using the wire nuts which are provided. **IMPORTANT:** When using wire nuts be sure to hold the wire ends parallel and together but do not

twist them. Insert these ends into the opening of the nut, pushing firmly and turning nut in a clockwise direction until the connection is securely made.

5. Remove the wires from the "G-G" terminals on the pre-amplifier, and connect them to the screw terminals of the terminal box. **NOTE:** In the case of Hammond models B-3, C-3, and RT-3 all connections at the pre-amplifier are solder-type connections.
6. Attach the red and black wires from the terminal box to the "G-G" terminals on the pre-amplifier which were vacated in step 5.
7. Attach the yellow wire from the terminal box to any convenient ground screw.
8. The *brown wire* from the terminal box is to be connected on the basis of the Hammond model involved:

Models A, B, C, D, E, BV, and CV only:

Attach to the pre-amplifier B+ terminal along with the wire (to the cable outlet box) already connected there.

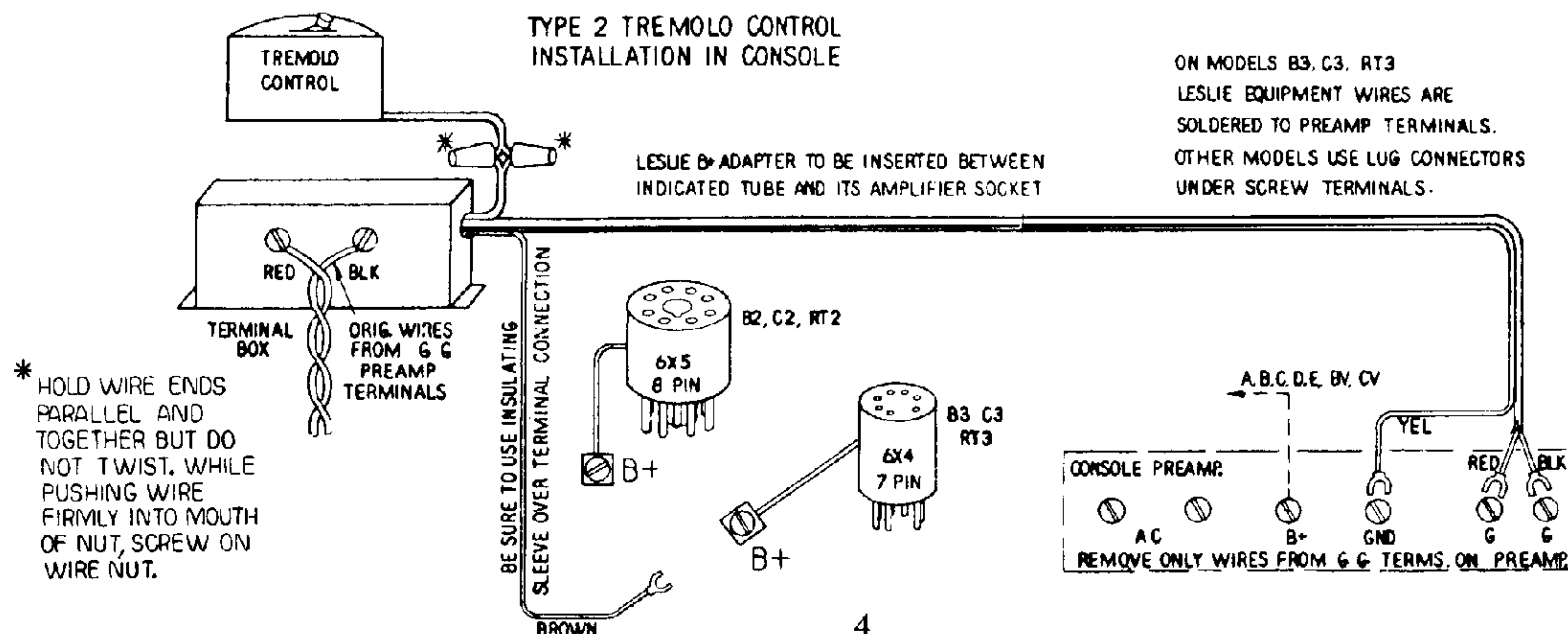
Models B-2, C-2, and RT-2 only:

Attach to the brown wire on the Octal Tube Adapter (Part No. 428-9) which is furnished as a part of the 428 kit. Once the connection is made push the plastic insulating sleeve over the terminal. Remove the 6X5 tube from its socket on the pre-amplifier chassis, plug the adapter into this socket, and the 6X5 tube into the socket on the adapter.

Models B-3, C-3, and RT-3:

Attach to the brown wire on the 7-pin adapter (Part No. 428-8) which is furnished as a part of the 428 kit. Once the connection is made push the plastic insulating sleeve over the terminal. Remove the 6X4 tube from its socket on the pre-amplifier chassis, plug the adapter into this socket, and the 6X4 tube into the socket on the adapter.

9. Complete the installation by connecting console and Leslie Speaker, using the cable which is supplied with the Hammond console. The plug at one end of the cable is to be connected to the socket on the outlet box in the console; the receptacle at the other end of the cable plugs into the amplifier on the Leslie Speaker. The installation is now complete except for the regulation of the volume, as may be required. The volume control should be set according to detailed instructions on page 5.



VOLUME CONTROL SETTING

The Leslie amplifier is designed purposely to have more gain than is normally required. Thus, a broad volume range is available. Volume should be adjusted on the basis of the console signal output as well as for the particular acoustic environment.

The volume level should be set on the basis of maximum demand, avoiding distortion or overload:

1. Using a full registration, that is, with one set of manual drawbars and both pedal drawbars pulled out to position eight, play a pedal note and a full chord, with the Swell Pedal fully "open".

2. Advance the volume control on the Leslie amplifier from a minimum position up to a point where some distortion can be heard.
3. Back off the volume control setting just far enough to eliminate all the distortion. This then is the correct setting for maximum undistorted loudness, and no further adjustment will have to be made.

CAUTION: Distortion, if continuous, can seriously damage speaker components.

THE LESLIE TREMOLO

One of the unique aspects of Leslie Speaker design is the method for producing tremolo, or tremulant. Two rotary elements within the Leslie cabinet project the sound a full 360 degrees in a manner which results in a realistic acoustic tremolo. This patented system adds important musical values to the tone of the Hammond Organ, greatly enhancing its performance.

Tremolo Control

Tremolo in the Leslie Speaker is controlled by turning the power for the tremolo driving motors on and off. This is accomplished by means of a relay which is built into the Leslie amplifier. The two motors plug into AC outlets located on the amplifier.

It will be noted that there are actually *three* AC outlets, located together on the amplifier. However, only two of the outlets are under on/off control. The third outlet, located nearest to the volume control, is not affected by the relay, but instead supplies power whenever the organ and speaker are turned on. (Use of this outlet will be explained in the section on special tremolo effects.) The Leslie Speaker, as it is shipped from the factory, has the two motors plugged into the two controlled outlets.

Tremolo Rotor Cycling

When the Leslie speaker is first turned on, the rotors which are plugged into the controlled sockets will rotate for approximately 10 seconds and then will stop. If the Leslie tremolo switch is "on" the rotors will immediately start again, and will rotate continuously, so long as the switch remains "on".

This initial rotor cycling is completely normal and occurs only during the warm-up period. After this warm-up completely normal on-off control will be in effect.

Special Tremolo Effects

Some intriguing musical possibilities result from having the Leslie tremolo under only partial on/off control. In this alternative arrangement the lower (bass) rotor is kept constantly in motion, while the upper (treble) rotor is controlled independently by the Leslie tremolo on/off switch. To accomplish this the power plug from the lower driving motor is plugged into the third AC outlet previously mentioned. This outlet, located nearest to the volume control, is not affected by the Tremolo switch. It supplies power to the driving motor continuously while the organ is in operation.

The uncontrolled outlet in the 22R cabinet will be used whenever this cabinet is equipped with Reverberation kit. Thus, when the lower rotor is to be kept constantly in motion, this outlet should be supplied with a cube tap in order to accommodate plugs from both the reverberation amplifier and the lower tremulant rotor.

The unusual effects that can be obtained from this partial tremolo control arrangement become apparent when the Leslie tremolo switch is in "off" position. The upper tremolo rotor (treble) will remain stationary while the lower (bass) rotor will continue to turn. Through choice of registration and playing range, some effects of considerable contrast may be obtained.

For example, notes played in the top two octaves of the keyboard, using a brilliant registration such as Strings, will be channeled mainly through the treble rotor. With the tremolo "off" this rotor will not be in motion, hence these notes will have practically no tremolo. If at the same time (still with tremolo "off") notes are played in the lowest three octaves of the other manual, and using a bland registration such as "Tibia", the sound will be heard mainly through the bass rotor which is revolving and which will thus produce a full tremulant. The "solo" part may be played on either keyboard, with the "accompaniment" on the other. Due to the contrasting tremolo treatment which is given to the two individual playing ranges, with tremolo "off", the tonal difference between "solo" and "accompaniment" parts is quite substantial.

Utilization of these special tremolo possibilities will further be influenced by the vibrato system of the particular console. Where the instrument is equipped with electronic vibrato, the vibrato control knob should be set at Number 1. If the vibrato is controlled separately for the two manuals many combinations of acoustical tremulant and electronic vibrato become possible. A reasonable amount of experimentation here will reveal many interesting musical possibilities.

Early model consoles were equipped with an amplitude-type tremulant, and in many cases with a chorus generator as well. Both these devices alter the organ's signal in such a way as to make it incompatible with the Leslie tremulant. Hence, on these early Hammond consoles neither the tremulant nor the chorus generator system should be operated at the same time that the Leslie tremulant is being used.

On Series 3 consoles which are equipped with the Hammond Percussion, the Leslie Speaker makes possible many interesting tonal combinations. Since the electronic vibrato is not applied to the percussion output, the only tremulant will be supplied by the Leslie. The Leslie tremulant may be turned off for those effects that are best without tremulant, or it may be used to provide tremulant for such interesting effects as the "Vibra-harp". Again, reasonable experimentation with the combination of percussion and Leslie will result in the discovery of a great many usable new sounds.

CONNECTING CABLES

The "standard" type speaker-connecting cable, as supplied by Electro Music, contains six conductors. Current models of both the Hammond Organ and the Leslie Speaker actually use only five of the six conductors in this cable. However, all six conductors are used with early consoles and speakers. Since these units continue to be used in installations it seemed advisable to standardize on cable which would be adequate for all installation requirements. Adaptation to the individual speaker and/or organ model is then a matter of selecting the proper terminal connectors, as explained in the chart.

The 6-conductor connecting cable is supplied in standard 30-foot lengths complete with plugs and/or connector terminals.

The cable with 6-pole connectors at both ends is Leslie Part No. 727.

The cable with a plug at one end and "spade-lug" connector terminals at the other end is Leslie Part No. 3M-1.

To span distances between console and speaker of more than 30 feet, the cable from the console may be supplemented by one or more 727 cable assemblies connected together in series, used as extensions.

In certain installations a specific length of cable other than 30 feet is required. In such cases bulk cable should be ordered, along with the necessary connectors, as specified in the parts list. (Note: The spade lugs should be obtained from a local radio parts supplier.) In attaching the cable to the connectors or to the "spade-lug" connector terminals be sure to follow the color coding as shown in the cable chart below. Special care should be given to the handling of all connections involving AC.

DESCRIPTION

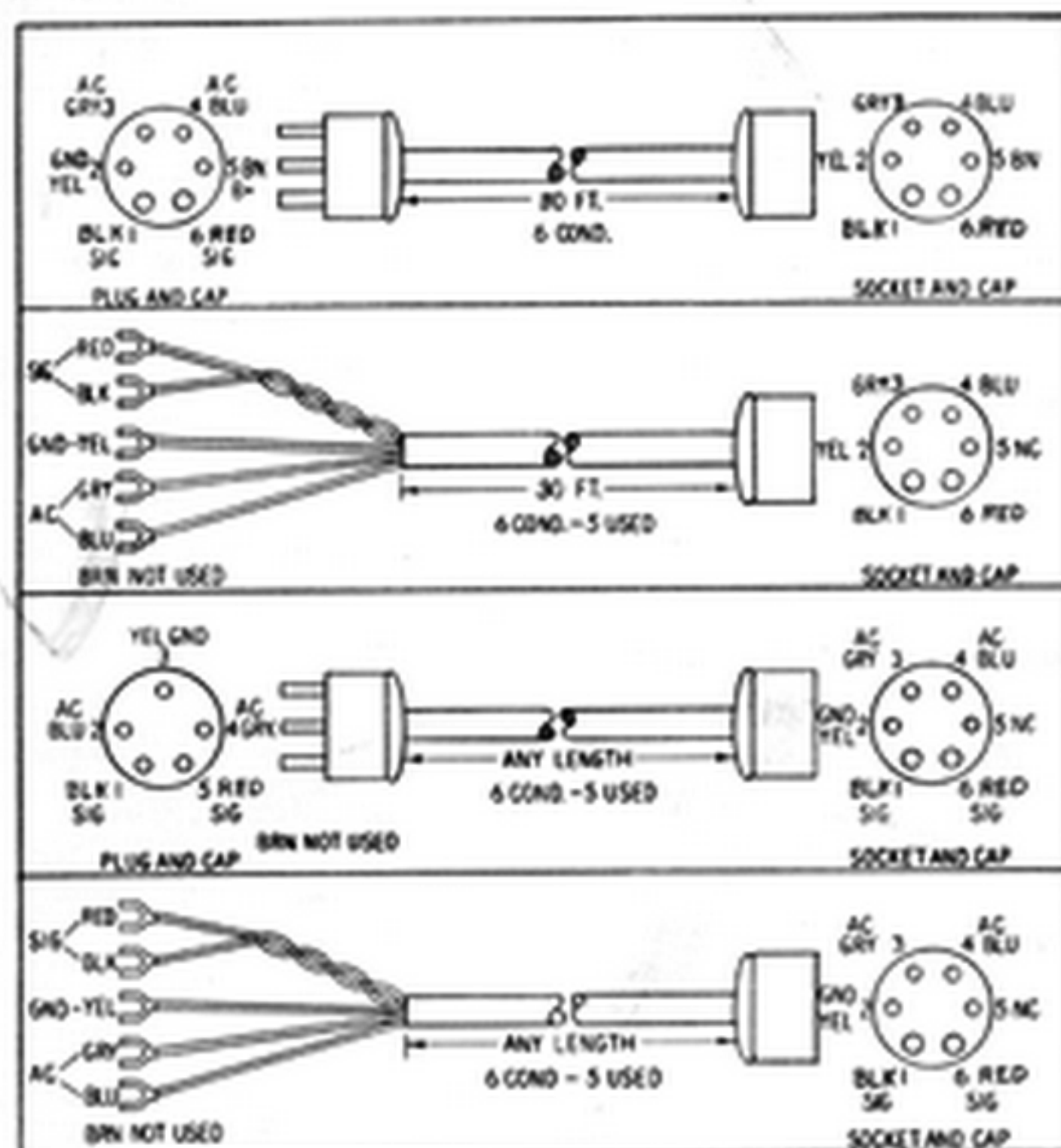
727 CABLE, COMPLETE
(INCLUDED IN A-100 KIT)

3M-1 CABLE, COMPLETE
(INCLUDED IN 3M KIT)

727-1 BULK CABLE (SPECIFY LENGTH)
727-3 SOCKET (6-CONTACT) AND CAP
727-4 PLUG (5-POLE) AND CAP

727-1 BULK CABLE (SPECIFY LENGTH)
3H ECHO CONTROL KIT INCLUDES:
727-3 SOCKET AND CAP
SPADE LUGS

ASSEMBLY DETAIL



USAGE

EARLY CONSOLE TO SPEAKER
EXTENSION - FROM CONSOLE
CABLE TO SPEAKER
EXTENSION - FROM SPEAKER
CABLE TO ANOTHER SPEAKER

CURRENT HAMMOND CONSOLE TO
CURRENT LESLIE SPEAKER

CURRENT CONSOLE TO
MAIN SPEAKER
CURRENT CONSOLE TO
ECHO SPEAKER
SPEAKER TO SPEAKER

CONSOLE TO ECHO SPEAKER

RECOMMENDED PERIODIC MAINTENANCE

The Leslie Speaker is carefully engineered for durability and minimum service. Periodic lubrication and a few simple checks will result in efficient operation.

Oiling

Oil the two tremulant motors by placing 20 to 30 drops of the oil which is furnished (or sewing machine oil) in each of the oil tubes at the back of the cabinet. The motors should be oiled every six months for normal usage, every three months for commercial usage.

The upper tremulant rotor should be oiled every year under normal operating conditions, every six months if in commercial usage. The oil hole is found at the center of the bakelite tremulant assembly, and is clearly marked. Place about five drops of oil in the hole, allowing it to drop slowly so as to avoid over-

flow at the opening. Be very careful to prevent oil from getting onto pulley grooves or driving belt.

Belts

For average service belts usually last several years. However, since frayed or badly worn belts can cause noise, they should be examined periodically, and replaced as necessary.

Tubes

Check periodically to see that all the tubes on the amplifier are illuminated, and are functioning properly. The weakening of tubes with long use is such a gradual process that the resulting sub-standard performance may not at first be noticed. New tubes, if carefully checked, will restore the speaker to its original operating efficiency. For best results it is recommended that the tubes be replaced before appreciable deterioration has occurred.

SPECIAL USES OF THE LESLIE SPEAKER

Broadcasting and Recording

To obtain full rich pipe-organ effects, the organ should be played at a fairly high volume, using a live studio. The microphone should be placed ten to fifteen feet away from the Leslie. For a smooth tremulant, adjust the microphone height so that it is either above or below the upper speaker louvres in the cabinet.

Non-Organ Use of the Leslie Speaker

The Leslie Speaker is a product of superb quality, designed solely and expressly for use with electric organs. It does not function satisfactorily in other applications. The unique musical characteristic of the speaker is the result of electrical and acoustical properties totally different from those found in "high-fidelity" sound equipment. This specialized concept upon which the Leslie Speaker is based restricts its recommended usage to the electric organ.

SHIPPING

The Leslie Speaker may be moved or carried in any position without special preparation. However, if it is to be shipped, the cabinet should be in an upright position, with shipping blocks in place to protect the motor, rotor, and the power amplifier.

In the case of the 22R, tape should also be used to hold the upper rotor down securely on its base. The reverberation unit also should be "locked".

INSTALLATION OF REVERBERATION UNIT IN THE MODEL 22R LESLIE SPEAKER

The Model 22R Leslie Speaker is functionally the same as the Model 22H; as shipped from the factory the 22R may be used in exactly the same way as the 22H. The 22R, however, is designed to receive the Hammond Reverberation Kit. All mounting holes are pre-drilled, and are properly located for easy installation of the major assemblies of the reverberation device. While it is preferable to install the 6X9 reverberation speaker on the right side of the Leslie cabinet (as viewed from the back), it may be that in the placement of the Leslie, this side of the cabinet is so close to the wall as to prevent the sound from radiating properly. In such cases the 6X9 reverberation speaker may be mounted in the left side of the cabinet, which is also supplied with louvres and pre-drilled holes. Complete installation details are provided for use of both speaker locations.

The Hammond spinet-type Reverberation Kit, with console-type speaker, includes all major assemblies as well as some of the small parts for the installation. The remainder of the parts are either contained in the kit of materials supplied with the 22R speaker, or will be found already in the cabinet. The following parts, included in the Hammond kit, are to be used in the installation — other parts may be discarded:

Reverberation amplifier with blue and black line cord attached.

Reverberation unit with blue and black wires attached.
Reverberation unit guide bracket.

Console-type 6X9 speaker with volume control and green and black wires attached. (Remove speaker from the wooden console speaker box.)

Amplifier shield base (aluminum foil.)

Two #4 x $\frac{3}{8}$ " sheet-metal type screws for guide bracket.

Six #8 x $\frac{5}{8}$ " sheet-metal type screws, for reverberation unit (2) and for speaker mounting (4).

NOTE: In addition to the usual service tools, the reverberation installation will also require use of "stubby" screwdrivers for the regular slotted-head screws and for the Phillips head screws.

Installation of the Hammond Reverberation device is to be made as described below. It is necessary that all three back panels be removed in order to provide unrestricted access to the interior of the cabinet. Specific directions (left, right) will be oriented on the basis of viewing the cabinet from the back.

1. Remove the four 10/24 x $\frac{7}{8}$ " machine screws from the amplifier mounting holes in the left-hand side of the upper shelf. Place the aluminum foil shield on this shelf, aligning the holes in the shield with the mounting holes in the shelf. Place the two felt strips at the ends of the shield, again aligning the holes in the felt with the mounting holes in the shelf. Mount the reverberation amplifier over the shield and the felts, with the terminal strip facing the horn assembly. Fasten the amplifier in place using the previously removed machine screws. Fasten at three points, but not at the right rear corner of the amplifier chassis. The bracket for the volume control is to be installed there, as will be explained in step number 8.
2. Take out right-hand wood speaker-cover box by removing the wing nut and angle bracket which hold it in place.
3. Mount the reverberation unit guide bracket assembly on the shelf to the right of the bass speaker, using the pre-drilled mounting holes. Be sure that the springs in the assembly face away from the side of the cabinet. Fasten the assembly in place with two of the #4 x $\frac{3}{8}$ " screws.
4. Insert two of the #8 x $\frac{5}{8}$ " screws into the pre-drilled holes midway in the right side panel of the cabinet, and tighten them down to approximately $\frac{3}{32}$ " from the surface.
5. Insert the vertical channel of the reverberation unit between the springs of the guide bracket, then hang unit on the screws which were installed in step 4. Check to be sure that mounting slots of the reverberation unit are properly seated over the mounting screws and that the vertical channel is still in place between the springs of the guide bracket. Finally, tighten the mounting screws.
6. After the 6x9 speaker has been removed from the wooden console speaker box, it should be prepared as follows for installation in the Leslie cabinet:
 - a. Cut the green and black wires leading to the speaker volume control about $2\frac{1}{2}$ inches from the speaker. Strip about $\frac{1}{2}$ inch of insulation from the ends of the two wires leading to the speaker.

- b. Using wire nuts, connect the green and black jumper wires (furnished in the Leslie kit) to the two wires from the speaker. Speaker is now ready for mounting. (The volume control assembly previously cut off will be used later in the installation.) **IMPORTANT:** When using wire nuts be sure to hold the wire ends parallel and together but do not twist them. Insert these ends into the opening of the nut, pushing firmly and turning nut in a clockwise direction until the connection is securely made.
7. To mount the 6x9 reverberation speaker on the **RIGHT-HAND** side, simply locate it properly over the pre-drilled mounting holes behind the louvers on the right-hand side. Fasten in place using four of the #8 x $\frac{3}{8}$ " screws. Replace the wood speaker-cover box, threading the green and black speaker wires out through the slot in the box. Secure box in place, using the mounting bracket and wing nut removed previously. Should it be desirable to mount the reverberation speaker on the **LEFT-HAND** side, these steps should be followed:
 - a. Remove the bracket and the long screw which are used to secure the speaker-cover box in position, and remount these in the left side of the cabinet, using the pre-drilled holes.
 - b. Remove the wood cover behind the louvers on the left side of the cabinet, and install on the right side.
 - c. Remove the other cover from the left-side panel and place it over the two holes in the right side of the upper shelf, aligning the cover with the pre-drilled holes in the shelf. Fasten the cover in place with screws.
 - d. Mount the 6x9 speaker behind louvers on left side of cabinet, using pre-drilled holes and fastening in place with four of the #8 x $\frac{3}{8}$ " screws.
 - e. Replace the wood speaker-cover box, threading the green and black speaker wires out through the slot in the box. Secure box in place using the mounting bracket and wing nut previously removed.
8. Mount the speaker volume control and wire assembly (removed in step 6) on the metal bracket which is furnished. Locate the control and bracket assembly at right rear corner of reverberation amplifier, placing bracket base between felt and foil. Use 10/24 x $\frac{3}{8}$ " screw to secure both the amplifier and the bracket.
9. Using wire nuts, connect the green and black wires from the volume control to the green and black (jumper) wires from the 6x9 speaker.
10. Attach the green and black wires (from the volume control, and equipped with spade lugs) to the "speaker" terminals on the reverberation amplifier.
11. Connect the spade lugs on the ends of the black and blue jumper assembly (furnished in Leslie kit) to the driver terminals on the reverberation amplifier. Connect the opposite ends of these jumper wires to the black and blue input wires of the reverberation unit, covering these connections with the plastic sleeving which is also furnished.
12. Connect the shielded extension cable (from Leslie kit) between the output wires of the reverberation unit and the reverberation amplifier.
13. Connect the short brown wire (from Leslie kit) across the "Switch" terminals on the reverberation amplifier.
14. Remove the insulation covering the spade lugs at ends of the red and black Leslie amplifier output wires. (These wires come from the 2-pole connector assembly located on the left side of the bass speaker shelf.) Connect these wires, using the spade lugs, to the "Signal Input" terminals on the reverberation amplifier.
15. Attach the AC plug (from Leslie kit) to the blue and black wires from the reverberation amplifier. Plug into an AC socket on the Leslie amplifier, using the socket which is nearest to the volume control knob.
16. Dress all jumper wires together near the left side of the bass speaker shelf. Snap the plastic cable clip (from Leslie kit) around these wires and fasten to the left side of the cabinet, using the #8 x $\frac{1}{2}$ " screw. Thus secured, the wires cannot vibrate and create noise.
17. Replace all three backs on the Leslie cabinet. Unlock the reverberation unit by turning the lock rod which is accessible under the metal cover found near the right side of the center back cover panel of the Leslie. To **UNLOCK**, turn the rod $\frac{1}{4}$ turn to the right, bringing the slot of the rod to a vertical position. (To **LOCK** the reverberation unit, the rod is to be rotated $\frac{1}{4}$ turn to the left, so that the slot is horizontal. The unit should always be **LOCKED** whenever the speaker is being moved.)
18. Set the volume control for the 6x9 speaker so as to provide the desired amount of reverberated sound. The installation is now complete.

MULTIPLE SPEAKER INSTALLATIONS

When a particular installation requires greater volume than can be obtained without distortion from a single Leslie Speaker, additional units may be added.

Additional speakers bring an improvement in the musical quality as well as an increase in the overall volume. Adding speakers is like adding chests of pipes in a pipe organ: the sound is distributed over a broad area. This effect of "bigness" is most pronounced when the speakers in a multiple installation are separated from each other by fifteen to twenty feet. Also, the selection of a different pulley groove (upper motor) for each speaker provides contrasting tremolo effects, further enhancing the pipe organ effect.

A multiple speaker installation may include any type of Hammond tone cabinet, and early model Leslie Speakers along with the current Leslie models. Where reverberation is involved special handling is required. Although it is technically possible to pass the reverberated Hammond signal through the Leslie Speaker, it is not always the desirable course; in addition, the installation becomes extremely complicated. The preferable course, where reverberation is desired, is to use the Leslie Model 22R Speaker.

One of the principle differences between current and early Leslie models is in the tremolo control circuitry. Thus, where earlier Leslies are used in an installation, special procedures must be followed, as described on pages 12 and 13.

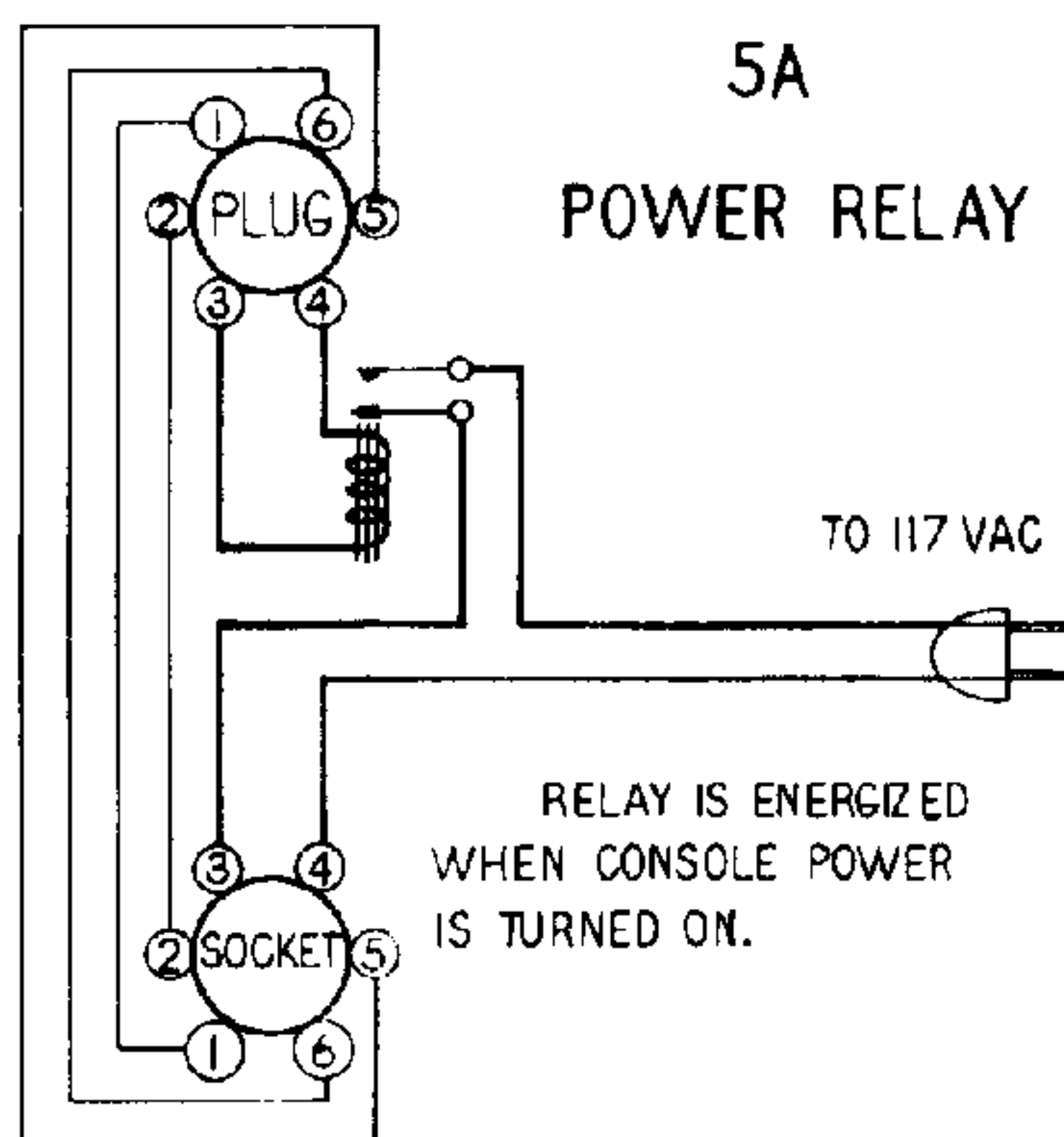
Tremolo, in a multiple speaker installation, may be controlled for all the current model Leslie Speakers, by a single on-off tremolo control switch. However, the use of two tremolo controls makes possible the independent control of the two Leslie Speakers or two groups of Leslies that may be used in the installation.

Power Requirements — Use of the 5A Relay

Although any number of speakers may be used together in an installation, the AC power requirements must be handled in such a way as to avoid overloading the console circuits. These circuits will quite easily power *one* Leslie or Hammond speaker, but for each additional speaker it is desirable to provide an outside source of power. To accomplish this, and at the same time to maintain complete on/off control through the console power switch, the Leslie 5A Power Relay should be used.

One of the 5A Power Relays should be attached to the input plug on each of the extra speakers. The connector cable plugs into the 6-pole plug on the relay and the AC cord from the relay is to be connected to a convenient electrical outlet.

Through use of the 5A Power Relay the console circuits are not overloaded, although power for all the speakers is turned on or off by the console switch.



Volume Control Settings on Multiple Speakers

In a multiple installation, the volume control for each one of the speakers should be set according to the instructions given previously. (See page 5). If the maximum levels thus obtained result in too much overall loudness further adjustments should be made.

It is most important that a balance be maintained between the several speakers that may be used in an installation. Each speaker should make approximately the same contribution to the total sound. No speaker should be allowed to overpower the others. Time spent in achieving the "right" adjustment for each speaker will greatly improve the final musical results.

Pedal Loudness

When two or more speakers are being used together

and are adjacent, they should be phased so that with individual pedal notes the speakers reinforce rather than cancel each other.

If improper phasing is suspected, try reversing the red and black output leads in the two-pole plug at the amplifier of one of the speakers. If louder pedal output results from this change it should be made permanent. However, if the pedal level is instead reduced, the original connection should be restored, and it may safely be concluded that the problem is acoustical rather than one of phasing.

Connecting Cables — Multiple Installations

Cable, when supplied with a Hammond console, is the 5-conductor type, with a 5-pole plug at one end for the console connection, and a 6-contact socket at the other end of the cable for the speaker connection. This cable may be used satisfactorily for any Hammond cabinets and for current models of the Leslie Speaker.

Early model Leslie Speakers and/or early model Hammond Organs necessitate use of 6-conductor connecting cables. This standard Leslie cable is available in bulk quantity (Leslie Part No. 727-1) or in 30-foot lengths complete with 6-pole connectors at each end (Leslie Part No. 727). The 6-conductor cable may be used throughout an installation, for the Hammond speakers and for all models of the Leslie Speaker. Where only 5 conductors are required a 5-contact socket is provided for the cable connection. The 6-pole plug on the end of the connecting cable must then be fitted with a 5-to-6 Adapter (Leslie Part No. 727-5) to permit the connection to be made.

Detailed information for handling specific cable connections, and for preparing cables, will be found in the chart on page 6.

Early Model Leslie Speakers

Tremolo rotors in the early model Leslie Speakers are started and stopped by a control current which is carried over the sixth (B+) wire in the connecting cable. Tremolo control in the current model Leslie Speakers is accomplished by means of a DC voltage which is superimposed on the signal lines. This is known as the "Type 2 Tremolo Control system".

Special circuitry in current Leslie amplifiers uses this superimposed DC voltage for control purposes, yet isolates it from the signal input grids. Amplifiers in early model Leslie Speakers and in Hammond tone cabinets do not use this voltage, nor do they have the necessary isolation circuitry.

Early Leslie Speakers are those with serial numbers below 5200. Some of the 31 series Leslie Speakers are in this category. However, most of the 31 series, as well as all of the 21H, and the present 22H and 22R models, are all categorized as "current" models. They all utilize the Type 2 Tremolo Control system, and are easily recognized as current models since the serial numbers are above 5200.

Tremolo control in installations involving early model Leslie Speakers must be given special handling. The DC voltage used for on/off control in the current model Leslie Speakers will not provide the same control in the early Leslie. In fact, the DC voltage *must be completely isolated* from the early Leslie, or hum, low output, and distortion will result. Isolation of the DC control voltage from the early Leslie is accomplished through use of the Type 2 Adapter.

The Type 2 Adapter prevents the DC control voltage from reaching the early model Leslie Speaker amplifier, yet at the same time keeps this voltage available for additional current model Leslie Speakers, so that they will have fully controlled tremulant operation. The adapter doesn't affect amplifier operation in any way. However, it does change the impedance value on the amplifier's extra speaker socket. Therefore, any additional speaker following the adapter must have its cable connected to the socket on the adapter box, rather than to the extra speaker socket on the amplifier.

The tremolo rotor operates continuously in any early Leslie Speakers on which the Type 2 Adapter is used. Where full tremolo control is required for the early Leslies, the console should be equipped with a 228 Tremolo Control. This would be in addition to the Type 2 Tremolo Control (428) which would still be required to control the current Leslies.

The Type 2 Adapter must be used with earlier Hammond tone cabinets in all cases where those units are connected to the channel (Echo or Main) which is supplied with the DC tremolo control voltage. However, the Type 2 Adapter *should not be used* with Hammond tone cabinets Type PR and later. For these units it is necessary to keep one of the channels completely free of the DC tremolo control voltage; by connecting the Hammond tone cabinets to this channel the need for the Type 2 Adapter is eliminated. Such an installation, illustrated in Figure 2, page 12, is actually preferable for *all* Hammond tone cabinets. However, it is mandatory for the PR (and later) series, and is the only satisfactory arrangement for using these particular tone cabinets in conjunction with current model Leslie Speakers.

Modification of Early Leslie Speakers

Early Leslie Speakers may be modified and thus made fully compatible with the current model Leslie Speakers. The modification must be done at the Electro Music factory, and since all changes are made within the amplifier, this is the only part of the Leslie Speaker that need be sent to the factory.

The Type 2 Tremolo Control circuitry which is installed at the time of modification is functionally identical to that of the current Leslie models. The same 428 Tremolo Control kit may be used, and the Type 2 Adapter is no longer necessary. Since the 428 Tremolo Control kit is *not* automatically supplied as a part of the modification "package" it should be ordered separately if required.

MULTIPLE INSTALLATIONS IN DETAIL

In the following several pages details are given for the various types of multiple speaker installations. The techniques for combining current model Leslie Speakers with early model Leslies and/or Hammond tone cabinets are fully explained and illustrated. Finally, several typical installation layouts are provided, as a means for summarizing principles which must be followed in multiple installations:

1. To provide AC power for the second and all additional speakers used in an installation, a 5A Relay should be used at the amplifier of all but the first speaker.

Echo (Speaker Selector) Controls

The use of multiple speakers in an installation not only results in greater sound volume, but also makes possible improved sound distribution. To this end, the several speakers that may be used in an installation are usually separated from each other by a reasonable distance. Or, where the installation is quite sizeable, the speakers are arranged together in groups which are in turn separated from each other.

Since it is usually desirable that the organist be able to use the speakers selectively, an "Echo Control" is used to accomplish this purpose. The Echo Control is in effect a switching device that permits the organist to select the speaker or speakers that will be heard. For the purpose of convenient identification, the speaker or speakers located nearest to the console are usually designated as "Main" speakers. The speaker or speakers located at a point more remote from the console are then referred to as "Echo" speakers.

Multiple speaker installations normally involve the larger Hammond consoles — those without any built-in speaker systems. Where an Echo Control is used with these Hammond models, it should be the type 3H control. If, for reason of availability, it is desirable to use some switching mechanism other than the recommended Leslie 3H Echo Control, the circuitry must be modified as necessary so that it is identical to that of the 3H control. (See diagram page 15.)

Multiple installations with Hammond models having built-in speaker systems will not afford the organist the complete flexibility of speaker selection as will be the case with the larger Hammond models. The former Hammond Models, specifically the Models M and A-100, employ an Echo Control (types 3M and A-100, respectively) for the purpose of channeling the sound either through the console speaker or through the Leslie Speaker. Additional Leslie or Hammond speakers may be connected to the first Leslie Speaker, and will be heard simultaneously with it. Since one position of the Echo Control switch is reserved for the console speakers the other position will necessarily activate all the external speakers. Further selective channeling on these Hammond models with built-in speakers becomes extremely complicated and therefore is not recommended.

2. Early model Leslie Speakers and early Hammond tone cabinets, when connected through the channel that is affected by the 428 Tremolo Control, must be connected by means of the Type 2 Adapter, so as to isolate the tremolo control voltage from these particular units.
3. The Type 2 Adapter need not be used with early model Leslie Speakers and Hammond tone cabinets, providing these speakers are connected to the channel which does not at any time receive the tremolo control voltage.
4. Full tremolo control for any early model Leslie Speakers will result only from the use of the Type 228 Tremolo Control. Otherwise, the early model Leslie Speakers will produce a constant tremulant.

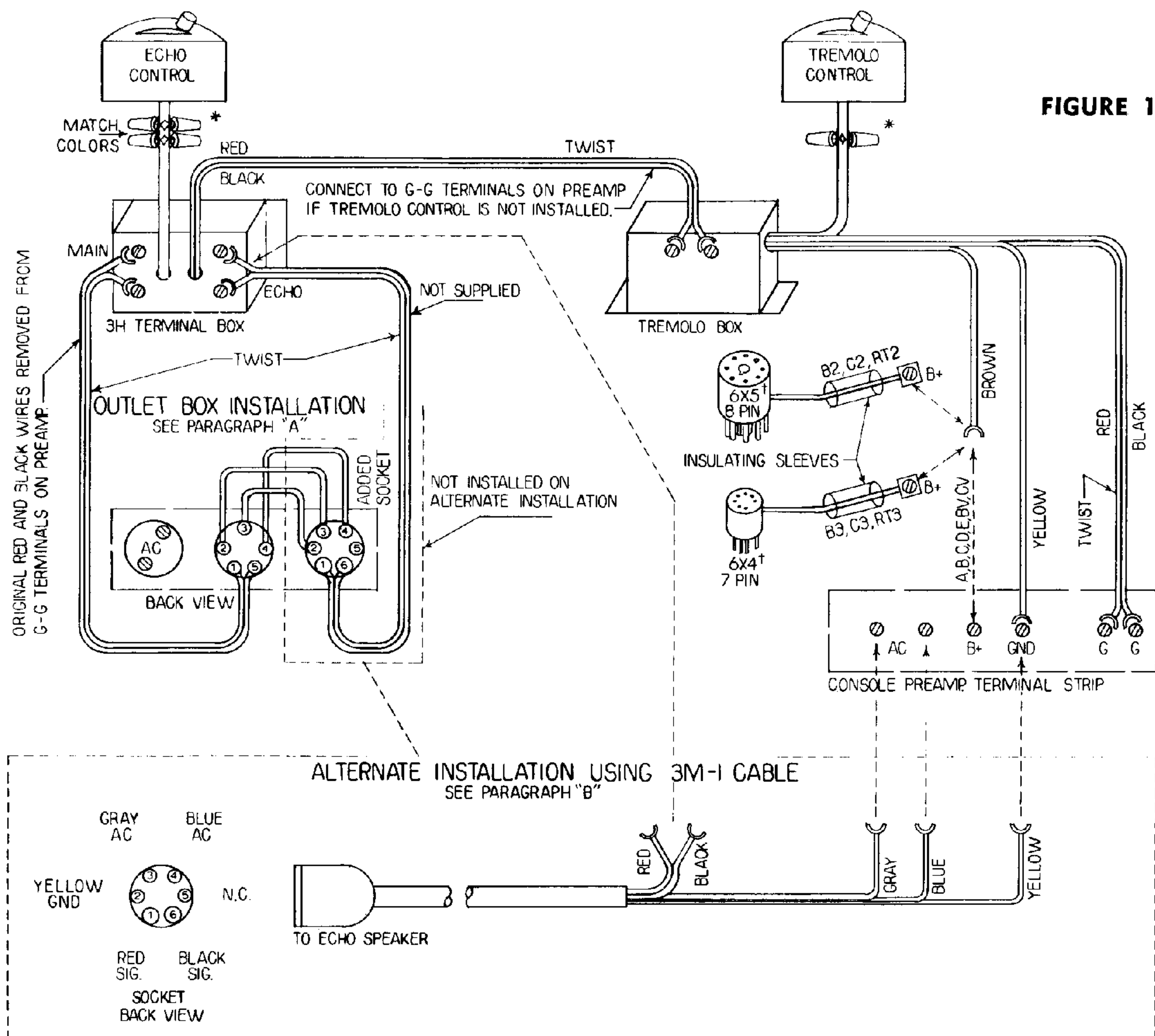
Installation of the Leslie 3H Echo Control

For Hammond Models: A, B, C, D, E, BV, CV, B-2, C-2, RT-2, B-3, C-3, and RT-3

1. Attach the echo control case to the wood rail directly in front of the lower manual, choosing the two mounting holes in the control case which best center the wood screws in the rail. Use the screws which are provided. The echo control may be mounted at the right end of the rail, or at the left beside the tremolo control.
2. Mount the echo terminal box inside the generator compartment near the pre-amplifier.
3. The echo control cable should be passed into the interior of the console, using the same method as was chosen for the tremolo control cable. Instructions for the latter will be found on page 4, item 2.
4. Provision for attaching the speaker connector cable should be made in one of two ways:
 - a. If an outlet box is provided in the console for the speaker connection, remove one of the metal

knock-outs and install either a 5-contact socket if Hammond cable is to be used, or a 6-contact socket (furnished with the 3H kit) if the Leslie 727 cable assembly is used. (If the outlet box is already equipped with a second 5-contact socket, use of the 727-5 Adapter makes it possible to attach the 6-pole plug of the Leslie 727 cable assembly.)

- b. If the outlet box method of connection is not used, the speaker cable may be fed into the generator compartment through a small notch that can be made in the bottom shelf of the console. In this method, the 3M-1 cable is recommended for use. The 3M-1 is a 30-foot assembly, complete with the necessary connectors. For cable lengths other than 30 feet, bulk cable should be used. The needed connectors (6-contact socket and spade lugs) are regularly included in the 3H Echo Control kit.
5. Complete the remaining connections for the Echo Control installation according to the diagram below:

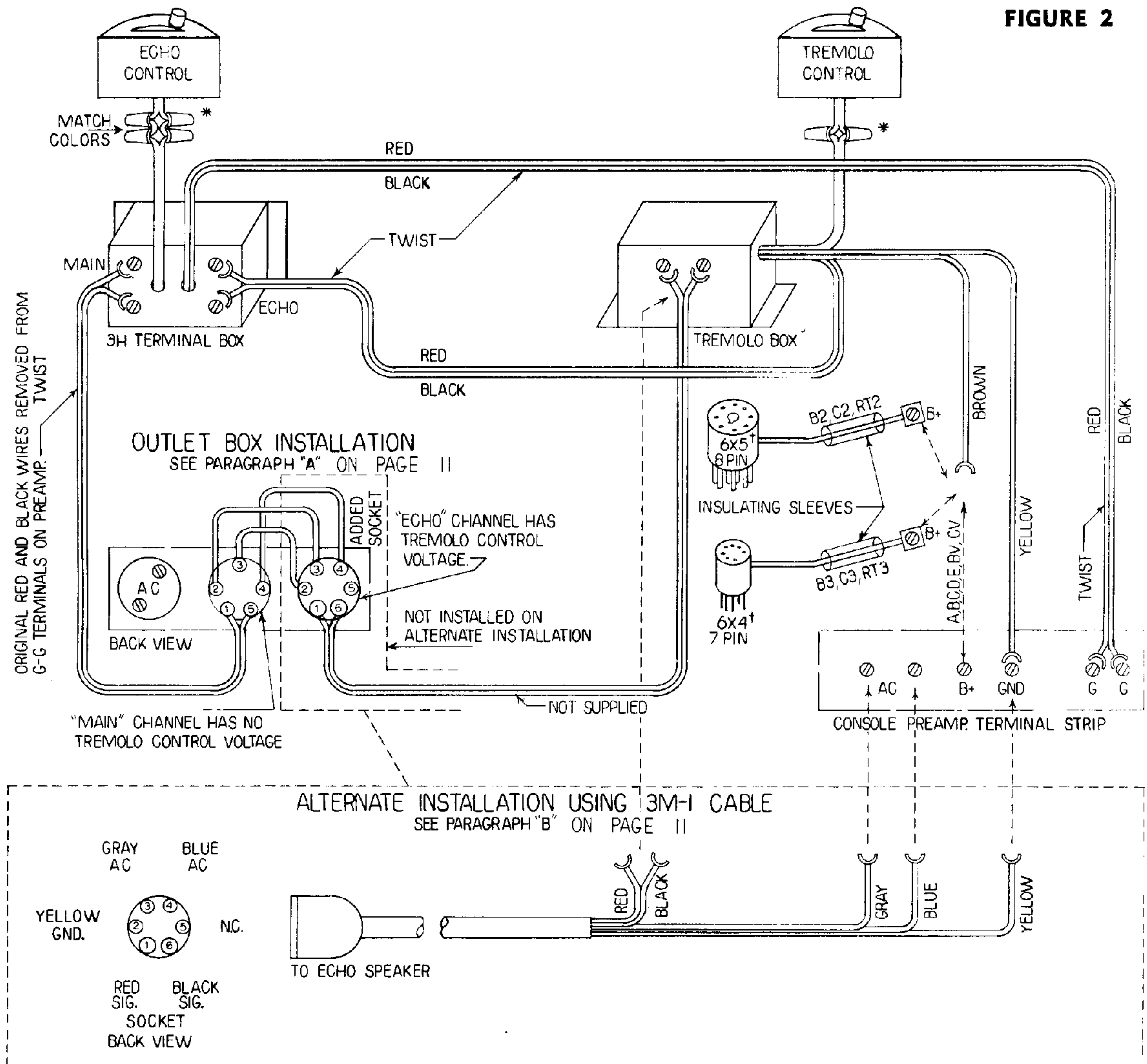


Special Handling of DC Tremolo Control Voltage

The installation shown in Fig. 1 introduces the DC tremolo control voltage at a point in the circuit which causes it to be present in both the Main and the Echo speaker channels. For this type of installation it is generally assumed that only the current model Leslie Speakers will be used in the installation. However, in those installations where the speaker or speakers on one of the channels are either Hammond tone cabinets, or early Leslies, or both, the Tremolo Control should be installed in a different manner.

Since it is desirable to keep the DC tremolo control voltage out of the channel which includes Hammond tone cabinets and/or early Leslies, the Tremolo Control should be connected into the circuit *following* the Echo Control, as shown in the installation sketch be-

low. This particular arrangement assumes that the current model Leslie Speakers will be connected to the Echo channel, whereas the early Leslie Speakers and/or any Hammond tone cabinets will be connected to the Main channel. *In this way the Type 2 Adapter need not be used.* However, if for any reason it becomes necessary to use early Leslie Speakers or Hammond tone cabinets on the Echo channel, the tremolo control voltage *must be isolated* through the use of a Type 2 Adapter. The Type 2 Adapter, when used, is connected to the amplifier which is to be isolated from the DC control voltage, the connection being made at the plug which would otherwise receive the cable from the console. This cable then plugs into the Type 2 Adapter. (See "Early Model Leslie Speakers", page 9.)



* WIRE NUTS
HOLD WIRE ENDS PARALLEL AND TOGETHER BUT DO NOT TWIST.
WHILE PUSHING WIRES FIRMLY INTO MOUTH OF NUT, SCREW ON
WIRE NUT.

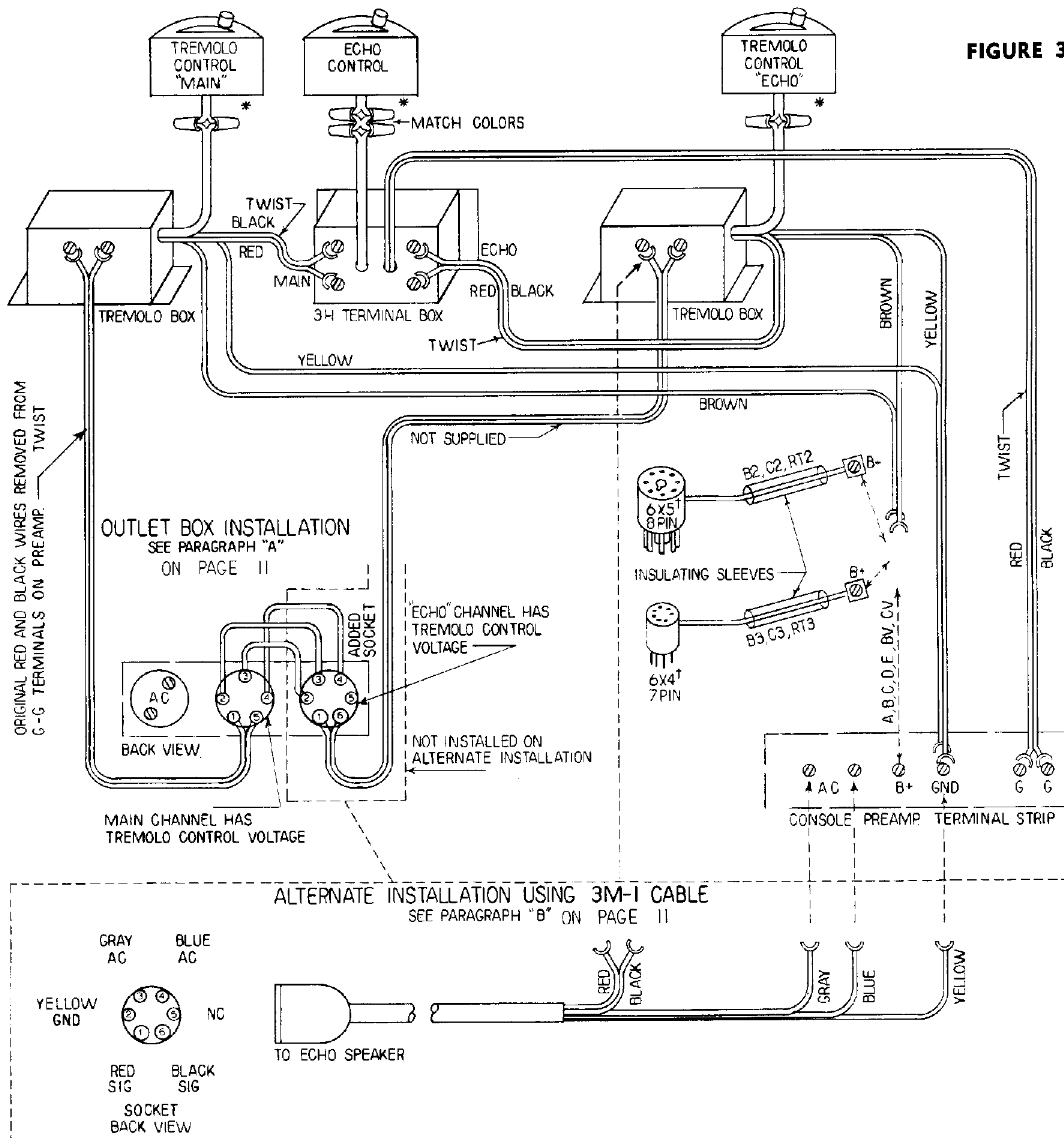
Multiple Tremolo Control

Tremolo for two Leslie Speakers, or for two groups of Leslie Speakers, may be controlled independently by the use of two tremolo controls, connected as shown in the diagram below. Since both these controls are the Tremolo Controls, the DC tremolo control voltage will be present in both the Echo and the Main channels. As noted previously, the Type 2 Adapter must be used to isolate this DC tremolo con-

trol voltage from any early model Leslie Speakers or early Hammond tone cabinets that may be used in either channel. Hammond tone cabinets, series PR and later, may not be used in this type installation.

When early model Leslie Speakers are used in an installation and it is desirable to control the tremulant on these units, a 228 Tremolo Control must be used. This control may be obtained from Electro Music, together with complete instructions for its installation.

FIGURE 3



* WIRE NUTS
HOLD WIRE ENDS PARALLEL AND TOGETHER BUT DO NOT TWIST.
WHILE PUSHING WIRES FIRMLY INTO MOUTH OF NUT, SCREW ON
WIRE NUT.

GENERAL GUIDE FOR MULTIPLE SPEAKER INSTALLATIONS

KEY TO ACCESSORY AND CONNECTOR DESIGNATIONS

2A-TYPE 2 ADAPTER

5A- LESLIE POWER RELAY

5P- PLUG, 5 POLE

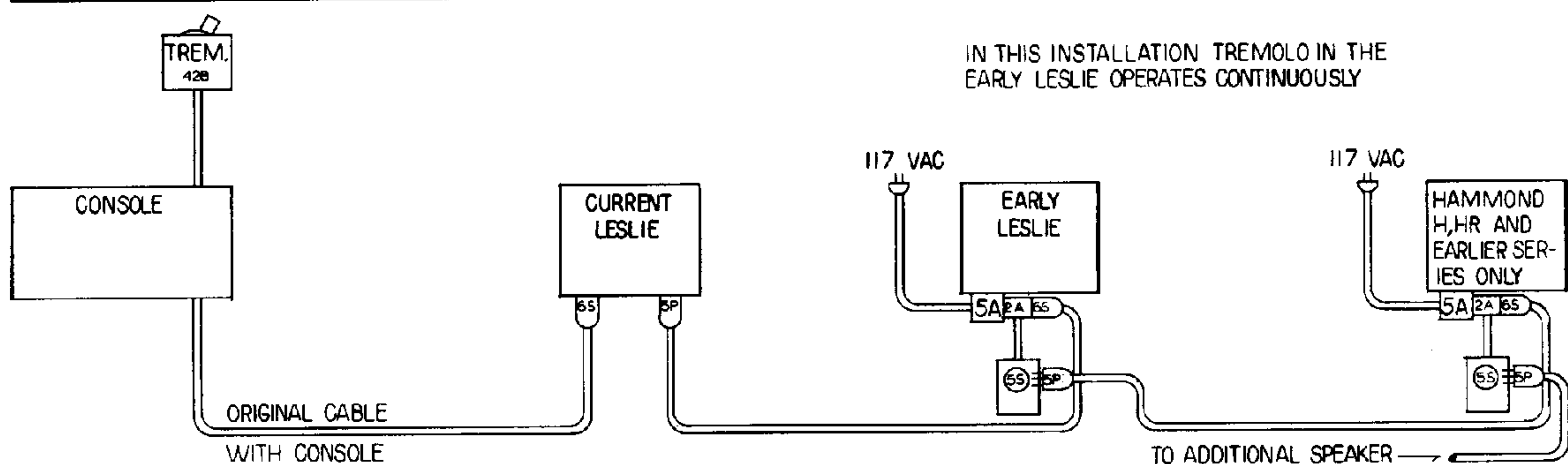
5S-SOCKET, 5 POLE

6S-SOCKET, 6 POLE

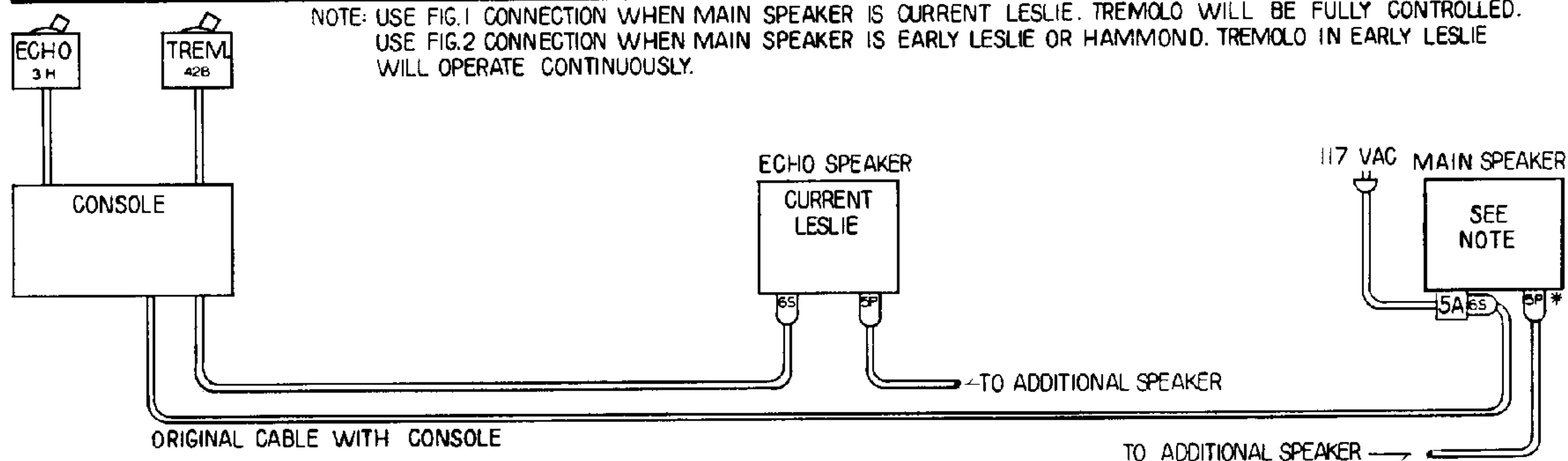
EARLY LESLIE -SERIAL BELOW 5200

CURRENT LESLIE-SERIAL ABOVE 5200

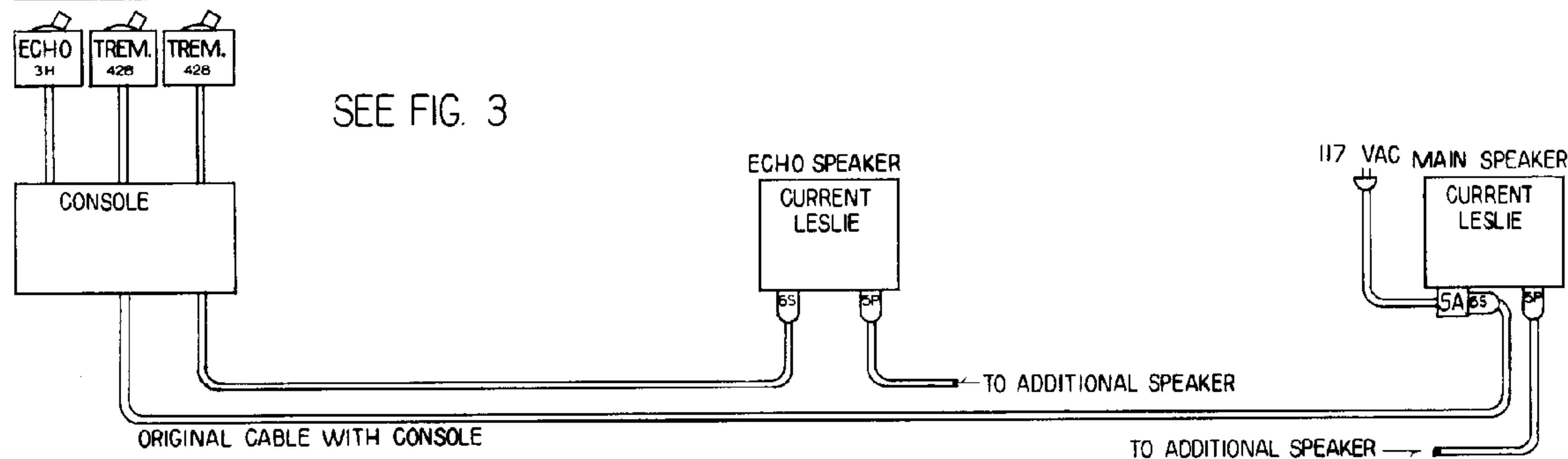
(INCLUDES 21H AND LATE 31H)



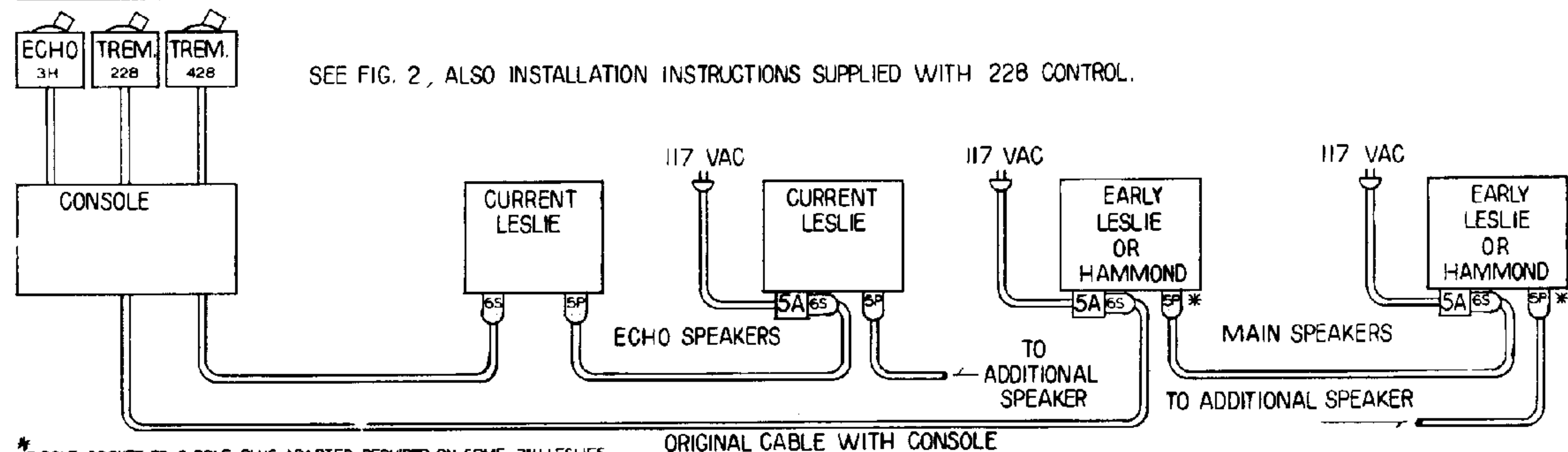
NOTE: USE FIG.1 CONNECTION WHEN MAIN SPEAKER IS CURRENT LESLIE. TREMOLO WILL BE FULLY CONTROLLED.
USE FIG.2 CONNECTION WHEN MAIN SPEAKER IS EARLY LESLIE OR HAMMOND. TREMOLO IN EARLY LESLIE
WILL OPERATE CONTINUOUSLY.



SEE FIG. 3



SEE FIG. 2, ALSO INSTALLATION INSTRUCTIONS SUPPLIED WITH 228 CONTROL.



* 5 POLE SOCKET TO 6 POLE PLUG ADAPTER REQUIRED ON SOME 31H LESLIES

SERVICING AND TECHNICAL INFORMATION ON COMPLETE LESLIE SPEAKER CABINET

Replacement Parts for Servicing

Replacement transformers, filter chokes, and tremolo relays, should be obtained from the Electro Music factory. Standard type parts such as tubes, fuses, sockets, resistors, and condensers, can be obtained from radio parts supply stores. The detailed parts list with this manual will give full parts replacement information.

AMPLIFIER AND ELECTRICAL

Amplifier is removed from cabinet by taking out the one screw that holds the front end of the amplifier to the bottom of the cabinet. After the two motor plugs and speaker plugs are removed, the amplifier may be withdrawn. When pushing the amplifier back into place, align the back end of the chassis in approximate position so that the amplifier guide and hold-down clamp will engage the amplifier.

Fuse

The amplifier uses a replaceable Slo Blo 1½ amp. fuse to protect the power supply against most short circuits. Before replacing a blown fuse, determine the cause of fuse failure. Do not substitute a fuse having a higher current rating than that specified.

Screen Voltage Regulation on Power Tubes

This amplifier uses a new and relatively simple regulating circuit to hold the output tubes screens at the best operating voltage regardless of signal level variations. The result is maximum efficiency in getting the greatest useful power output for the total power consumed.

Gas regulator tubes will maintain a constant voltage drop regardless of current variations, within rated limits. By proper choice of gas tube relative to the power supply voltage, a closely held voltage is made available for the screens. Parts used and functions are as follows:

1. 0C3-VR105 Regulator tube provides constant voltage reduction in a series circuit to the output tubes screens.
2. 470 ohms 1/2 watt resistor—not critical in value. Acts to suppress possible gas tube oscillations caused by screen current variations. It also acts as a fuse in case of accidental screen circuit short.

Tremolo Control Malfunctions

Non-operation of the Leslie tremulant can be corrected by checking the following:

1. Make sure the tremolo control is wired into the circuit exactly as shown in the diagram for the type installation which is being made.
2. Check the connecting cable for shorts or other conditions which would alter the DC voltage superimposed on the signal line. It should be approximately 100 volts.
3. If a non-Leslie speaker selector (Echo) switch or Hammond cabinet is included in the hook-up, make certain the echo switch or cabinet connection

doesn't cause the superimposed DC voltage to be grounded out.

4. Should none of the above reveal the non-operation cause, then a detailed check of the Leslie tremolo circuit components both in the console and Leslie amplifier should be made against the wiring diagrams in this manual.

Operation of the Tremolo Control

The (428) tremolo control circuit superimposes a DC controlling voltage on the signal line to the speaker cabinets. This is used to actuate a tube operated relay circuit for turning power on and off to the tremulant motors without need of control wires from the console to the speaker cabinets.

The tremolo control box installed at the console has a DC isolation transformer in the signal line. Without affecting the organ generator or amplifier circuits in any way, a positive voltage can be applied to the speaker signal line at the transformer center tap. A 10 mfd. condenser at the center tap puts the signal line at low audio impedance to ground, and yet allows changes in DC potential.

The relay control tube is one triode of a 12AU7. This triode has the relay coil and a current limiting resistor in its plate circuit. The cathode is connected to the cathodes of the output tubes and so is about 25 or more volts above ground. With the grid at ground potential, this cathode potential cuts off the plate current flow. With a DC potential on the signal line greater than the biasing 25 volts, the grid is raised up to the cathode potential and the triode draws plate current to operate the relay.

The triode control grid has a one megohm isolating resistor. This resistor prevents the grid from being driven positive with respect to cathode, and also prevents any effect on the operation of the audio on the signal line. Because the resistor also acts as a limiter, the DC control voltage is not critical and allows circuit operation over wide variations in B+ and AC line voltages.

The furnished tube adapters used to obtain the controlling voltage from the organ amplifier, have internal dropping resistors which protect the power supply in case of an accidental short circuit.

Distortion

Distorted sound is often caused by a too high setting of the Leslie volume control. Amplifier gain is purposely greater than necessary, so low output consoles can still provide full sound power output from the Leslie. Arbitrary setting of this volume control at maximum will surely result in distortion when the organ swell control is fully opened. Instructions for properly setting the volume control are given in an earlier section of the manual.

Brilliance of Sound

A variation in high frequency output from the Leslie can be arranged. The amplifier includes a .001 mfd. capacitor from grid to grid of the balanced input stage. By changing the value of this capacitor, variations in brilliance of tone can be obtained

To increase brilliance, change the value to about 500 mmfd. or less. To decrease brilliance, shunt additional capacity across existing capacitor, or replace with a greater value to obtain desired balance. Do not change the output transformer primary shunting condensers.

Voltage Readings

If the amplifier develops difficulties resulting in malfunction or non-operation that is not remedied by tube or electrolytic condenser replacements, the various voltages should be measured and compared to the voltages shown on the circuit diagram. The voltages indicated were measured with a 20,000 ohms per volt voltmeter, and differences in meter resistance and line voltage variations as well as parts tolerances should be kept in mind. If any abnormally high or low voltage is noted, it usually indicates a defective part in the associated circuit.

Transformer Replacement

If the output transformer is replaced, the two plate leads should be as short as possible and lie close to the chassis.

Electrolytic Condensers

Practically all modern amplifiers contain electrolytic condensers. These have a definite life expectancy, and must eventually be replaced. The Leslie amplifiers use the finest electrolytic condensers obtainable, and experience has shown that many years of trouble free service can be expected.

In view of the fact that they will eventually wear out, most of the electrolytic condenser units on the amplifier are contained in a single plug-in unit that can be replaced as easily as a tube. The condenser is a four section 30-30-30-10 mfd. 475 volt unit.

Tubes

Tubes are a common source of amplifier difficulties, although it must be recognized that certain malfunctions which might at first appear to be caused by tubes, are actually the result of other conditions.

Checking in a tube tester will reveal certain tubes to be defective. However, replacement is also recommended for tubes which have been in service for a considerable period of time, as their performance will have deteriorated and the amplifier will not operate efficiently.

Tubes for replacement purposes may be obtained from a local source. However, for best operating results it is recommended that the 6550 power tubes be replaced as a pair, with units obtained from Electro Music. These tube pairs have been carefully tested and matched for use in the Leslie Speaker.

Line Voltage

Exceptionally low or high line voltage may cause difficulties with amplifier operation. If the line voltage falls below 100 volts, unsatisfactory performance will result. Low line voltage can be caused by poor contacts in the cable wiring or exceptionally long cable. Adding the Leslie 5A relay is an easy way to overcome low line voltage due to long cable.

Electric Brake

When the tremolo control switch is in off position, braking of the tremulant motors is obtained by having the control relay apply a direct current to the motors. During the off time, the direct current flows through the motors continually. No harm is done because the current is substantially below normal running ratings.

The DC braking voltage is obtained through a full-wave rectifier circuit in the primary of the power transformer. Components and functions are as follows:

1. Silicon diode rectifier (two used)
2. 100 ohm, 3 watt resistor
3. .1 mfd, 400 volt filter condenser
4. Suppressor coil—prevents switching clicks in speaker.

In the case of 22H cabinets with serial numbers below 22750 and 22R cabinets with serial numbers below 40900, a somewhat different brake circuitry will be found. In these units the DC braking voltage is obtained by means of rectifying and filtering a 25 volt tap on the power transformer primary. The components used, and their functions, are as follows:

1. Silicon diode rectifier
2. 200 mfd, 50 volt filter condenser
3. 3 ohm limiting resistor—protects silicon diode rectifier from current surges
4. Suppressor coil—prevents switching clicks in speaker.

LOUDSPEAKER SYSTEM AND DIVIDING NETWORK

The Leslie uses a full two way system with two separate speakers. Pedal and midrange tones are generated by a heavy duty 15 inch speaker with permanent magnet. Its nominal impedance is 16 ohms. Upper middle and highest tones are generated by a compression sound chamber driver unit also using permanent magnet. Its nominal impedance is 16 ohms.

The 15 inch speaker is mounted in a matched bass reflex enclosure. It is therefore important that the cabinet back is in place and securely fastened. The high frequency driver is loaded by means of a rotary horn. Only one of the horns in the upper rotor radiates sound. The other horn dynamically balances the assembly to eliminate vibration. A small cotton acoustic filter is placed in the throat of the horn. It also prevents dust from entering the driver unit. Do not remove this filter.

The two specialized range speakers are connected to the amplifier via a two half section M derived frequency dividing network (crossover). This network electrically separates the bass and treble range output of the amplifier, and directs the proper signal to each speaker. The nominal separation occurs at 800 cps. The impedances used in the loudspeaker system allow a dividing network design of extremely rugged and electrically stable parts. It is very unlikely that trouble will ever be experienced with this element.

Speaker Problems

Because of the extremely strong permanent magnetic fields with both speakers, it is inadvisable to attempt cone replacements or repairs involving dis-

assembly. The Electro Music factory will either repair a faulty unit or supply a replacement.

Should the treble speaker become inoperative for some reason, emergency operation of the cabinet can be arranged. Unplug the bass speaker from the dividing network and plug it direct to the amplifier output socket. There will, of course, be a lack in musical quality until the complete system is restored.

Suspected low output from the dividing network output can be checked by the same procedure as above.

MECHANICAL MAINTENANCE

Motor

After several years of typical service, or a reasonably long period in commercial use, the motors might accumulate lint and dust. This accumulation interferes with proper ventilation and oiling. Time invested in cleaning the motors is well repaid by longer life. The motors can be removed easily and cleaned with cleansing solvent.

Upper Motor Removal and Replacement

Remove the motor power plug from socket, and remove the two wing nuts. Then the motor can be removed from the cabinet. **IMPORTANT:** The upper motor must run counterclockwise when viewed from the top or pulley end. Otherwise, the upper tremulant rotor will not come up to speed. If the motor is disassembled or another motor substituted, the rotation should be checked to be sure it is *counter-clockwise*.

Lower Motor Removal and Replacement

Remove the motor power plug from the amplifier socket and remove the two wing nuts that hold it to the shelf. The motor will drop down for removal. When replacing this motor, first position the belt on the motor pulley before it is lifted into place onto the mounting screws. Because the front wing nut controls the tremulant drive belt tension, this must be adjusted whenever the motor is replaced. See "Belt Tension Adjustment" below.

Disassembly and Cleaning

For cleaning purposes, before a motor can be completely taken apart, the pulley, pulley support ring, and oil tube assembly must be removed. When removing the end covers, be sure to note or mark the position of the bottom end cover with respect to the laminations. If this should be rotated relative to its original position, bearing misalignment will result and the motor will be noisy or even hind.

After reassembly, if there is some noise during motor operation, it's probably due to temporary bearing unseating. A light tap with a fairly heavy tool on the laminations side will shake the assembly into proper position.

The mounting brackets used with the motors are adjusted to obtain $5\frac{3}{4}$ " between centers of mounting holes. If the brackets are bent, they should be straightened to obtain this dimension. Upper and lower motors are interchangeable if the proper pulley is used. Motor pulley is held on to the shaft by the center screw, and after this is removed, the pulley may be pulled from the shaft. The metal three groove

pulley is for upper rotor and the single groove pulley is for lower rotor use.

Belt Replacement

For average service, the belts usually last several years. In the event of any excessive belt wear, the pulley and mountings should be examined for rough surfaces or misalignment that might cause the wear.

Upper Belt Replacement

Remove the upper compartment cover and pre-stretch the new belt by pulling it out to full length. Place it over one horn and then the other alternately; then on desired motor pulley groove and idler pulley.

Three tremulant speeds are available by choosing one of the three grooves on the motor pulley. Center groove provides standard tremolo, upper groove a slow tremolo, and lower groove a fast tremolo.

Lower Belt Replacement

A frayed or worn lower belt can cause noise by striking the lower shelf or belt guard and should be replaced as follows: Remove the large center back and lower compartment cover. Along the rim of the bass speaker, remove the eight mounting screws. Remove the connecting cable plug from the dividing network. The bass speaker can now be lifted from the shelf and out of the cabinet. To avoid possible cone damage, lift straight up for a short distance.

Pull the exposed rotor support from shaft. Place the new belt on the large pulley and pass the rest of the belt between the rotor and shelf towards the driving motor.

Remove the (motor-holding) wing nut nearest the cabinet back to partially drop the motor. Temporarily, hook the new belt over the screw that had the wing nut.

Replace the bearing support on the rotor shaft and position the ends in the shallow locating channels at the speaker opening hole. Align the holes in the support with the speaker mounting holes in the locating channels.

Place the bass speaker back in position and install the two screws that hold the speaker at each end of bearing support. These screws should be just started in position and then the other six screws started. After all eight screws are in position, they may be tightened.

Place the new belt on the driving motor pulley and put the motor back in position using the original holding wing nut.

Belt Tension Adjustment

Adjust the belt tension by first loosening the front motor wing nut only, and pulling the motor assembly to the left until the belt is stretched. Release the assembly and the belt will assume its proper tension. Tighten the wing nut with the motor at this position.

Do not stretch the belt tight and set the adjustment at this maximum tension, as noise and hard starting will result. A correctly adjusted belt will slip some as the rotor first starts turning. This, however, is a normal situation, and the slippage disappears after the first few seconds' operation.

Idler Pulley

The spring mounted idler pulley provides proper belt tension, and in the event the spring mounting becomes bent, it should be readjusted by bending so that it is aligned with the belt.

Treble Speaker and/or Upper Tremulant Rotor Removal and Replacement

1. Remove upper cover and belt.
2. Remove center compartment back.
3. Remove treble speaker unit plug from dividing network.
4. Remove the three screws in the rim of the treble speaker unit and drop straight down and out. The upper tremulant rotor may be removed by turning it sideways.

IMPORTANT: When replacing these parts, be sure the rubber and metal thrust washers are on the spindle so that the tremulant rotor will operate at the correct height and bass tones will not produce thrust bearing noises. The rubber washer is first placed on the spindle and then the metal washer is placed on top of the rubber washer.

Horn Reflector Replacements

On a damaged reflector, cut the stand-off pins so they can be pulled out with a pair of slip joint or "gas" pliers.

In assembling the new reflector, make sure it is put on so the cut edge will be at the top of the horn when it is in operating position. To hold the reflector without rattling, use the special cement furnished by Electro Music.

Bass Speaker Removal and Replacement

Remove center compartment back and the screws in rim of bass speaker. Disconnect plug from dividing network. Avoid damage to cone by lifting speaker straight up for a short distance before taking out of cabinet.

Bass Rotor, Upper Bearing Replacement

1. Remove bass speaker.
2. Remove top half of bearing clamp. The ball bearing can now be lifted out and replaced.

After the bearing clamp nuts are tightened, if the new bearing is found to be slightly loose, remove the bearing support assembly from the cabinet. Disassemble, and bend the lower half of the bearing clamp so it will apply more pressure to the ball bearing.

Bass Rotor, Lower Bearing Replacement

1. Lay cabinet on floor so that bottom is accessible.
2. Remove the two screws that fasten the bearing mounting plate to the cabinet, and entire bearing assembly can be pulled from the shaft. Be sure to

save the flat metal washer between the rotor and lower bearing grommets. It is important that this washer be in place when bearing is reassembled.

3. Remove the top half of bearing clamp to replace the ball bearing assembly.
4. Upon reassembly of bearing holder to rotor shaft, make certain the flat washer is included between the rotor and bearing grommets.

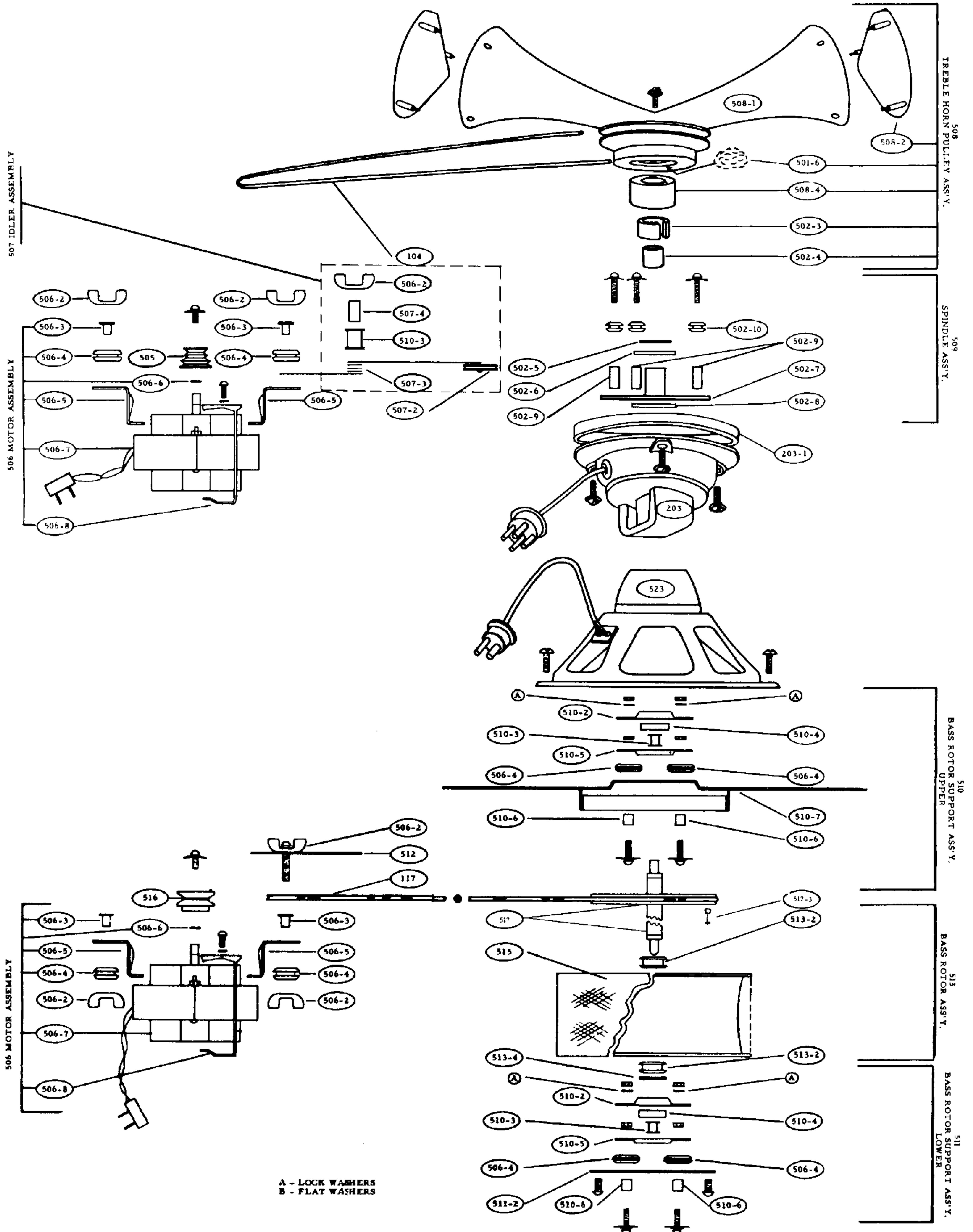
Bass Tremulant Rotor Removal and Replacement

1. Remove bass speaker.
2. Remove upper bearing support and belt.
3. Using the large pulley as a handle, remove the tremulant rotor shaft by twisting and pulling up at the same time. The tremulant rotor then will be freed to be removed towards the back of the cabinet. Be sure to save the metal flat washer found between the bearing and rotor grommets.
4. Replace the tremulant rotor with the sound deflector surface curved downward. Make certain the flat metal washer is in place between the bearing and rotor bottom grommets. When replacing the rotor shaft to the rotor, a little oil or Vaseline may be used as a lubricant. Grommets are made of Neoprene and will not be damaged by such lubricants.

When inserting the shaft and pulley assembly be sure the two drive pins, located on the pulley, straddle the rotor spoke which is supported by the curved sound deflector. When inserting the shaft, hold the rotor in a position that will allow the lower shaft end to enter the bearing grommet without displacing the flat metal washer between the bearing and rotor grommets.

To simplify the alignment of the shaft with the lower bearing, it may be easier to place the cabinet on the floor and remove the lower bearing assembly as in replacing the lower bearing. Also, in this way, it can be determined that the washer between the ball bearing grommet and the tremulant rotor grommet is properly in place.

LESLIE SPEAKER PARTS IDENTIFICATION CHART



PARTS LIST

LESLIE ORGAN SPEAKERS, MODEL 22H and MODEL 22R

IMPORTANT: Parts should be ordered by number. Also, to insure receiving the correct parts, it is important to supply the serial number of the Leslie Speaker on which the parts are to be used. Be sure to state color when ordering switch cases or complete switch assemblies.

EQUIPMENT USED AT HAMMOND CONSOLES

428 Tremolo Control, complete

(Case colors: brown, ivory, ebony)

- 428-1 Tremolo switch assembly with cable attached, plastic case, and knob. Case colors: brown, ivory, ebony.
- 429-1 Tremolo electrical switch only.
- 428-3 Plastic case only, with cover - brown
- 428-4 Plastic case only, with cover - ivory
- 428-5 Plastic case only, with cover - ebony
- 428-6 Push-on knob for switch - brown
- 428-7 Push-on knob for switch - ebony
- 428-10 Switch retainers—two used
- 428-12 Tremolo terminal box
- 428-2 Tremolo isolation transformer
- 428-8 B+ adapter, 6x4 (small)
- 428-9 B+ adapter, 6x5 (large)

3H Echo Control, complete

(Case colors: brown, ivory, ebony)

- 3H-1 Echo switch assembly with cable attached, plastic case, and knob. Case colors: brown, ivory, ebony.
 - 3H-5 Echo electrical switch only
 - 3H-2 Plastic case only, with cover - brown
 - 3H-3 Plastic case only, with cover - ivory
 - 3H-4 Plastic case only, with cover - ebony
 - 428-6 Push-on knob for switch—brown
 - 428-7 Push-on knob for switch—ebony
 - 428-11 Switch retainers—two used
 - 3H-7 Echo terminal box
- Note: Cable for connecting Leslie Speaker to console not included in 3H kit, but should be ordered separately as required.

3M Echo Control, complete

(Case colors: brown, ivory, ebony)

- 3M-3 Echo switch assembly with cable attached, plastic case, and knob. Case colors: brown, ivory, ebony.
- 3H-5 Echo electrical switch only
- 3H-2 Plastic case only, with cover - brown
- 3H-3 Plastic case only, with cover - ivory
- 3H-4 Plastic case only, with cover - ebony
- 428-6 Push-on knob for switch—brown
- 428-7 Push-on knob for switch—ebony
- 428-11 Switch retainers—two used
- 3M-4 Echo terminal box
- 3M-1 Cable assembly, 6-conductor, 30-foot length with all necessary connectors
- 3M-2 Speaker plug adapter—for M-3 consoles

A-100 Echo Control, complete

(Case colors: brown, ivory, ebony)

- 3H-1 Echo switch assembly with cable attached, plastic case, and knob. Case colors: brown, ivory, ebony.
- 3H-5 Echo electrical switch only
- 3H-2 Plastic case only, with cover - brown
- 3H-3 Plastic case only, with cover - ivory
- 3H-4 Plastic case only, with cover - ebony
- 428-6 Push-on knob for switch—brown
- 428-7 Push-on knob for switch—ebony
- 428-11 Switch retainers—two used
- 727 Cable assembly, 6-conductor, 30-foot length, with connector plugs installed
- 727-5 Adapter: 5-pole plug to 6-contact socket
- 3H-6 Extension cable, 30" twisted pair

INSTALLATION ACCESSORIES

- 727 Cable assembly, 6-conductor, 30-foot length, with connector plugs installed
- 727-1 Six-conductor bulk cable, less connectors, to specified lengths
- 727-2 Six-pole plug and cap, for 727-1 cable
- 727-3 Six-contact socket and cap, for 727-1 cable
- 727-4 Five-pole plug and cap, for 727-1 cable
- 727-5 Adapter: 5-pole plug to 6-contact socket
- 3M-1 Cable assembly, 6-conductor, 30-foot length, with six-contact socket at one end, and spade lugs at other end
- Type 2 Adapter, for early Leslie Speakers and Hammond tone cabinets, where needed
- 5A Power Relay, for multiple speaker installations

PARTS FOR 22H, 22R LESLIE ORGAN SPEAKER

NOTE: Sockets, connectors, and standard value components (resistors, condensers) are available through local electronic supply houses. Most of the "hardware" items, (bolts, nuts, screws) are also locally available. Parts listed below are mainly non-standard items, or components with close tolerances which should be obtained from Electro Music.

22H Amplifier

- *525-9 Power transformer
- †525-1 Power transformer
- 525-10 Output transformer
- 525-11 Filter choke
- *525-26 Diode rectifier assembly, complete
- * 25-5 Silicon diode
- 525-5 Chassis mounting strip (2 used)
- 525-6 Rubber shoulder bushing (4 used)
- 525-7 Metal bushing (4 used)
- 525-12 Relay
- 510-6 Bushing, relay mounting
- 502-10 Rubber grommet, relay mounting
- 525-13 Motor outlet socket (3 used)
- 525-21 Filter condenser socket
- 730-3 Speaker socket
- 725-15 Filter condenser, plug-in type, 30-30-30-10 mfd. 475 volt
- 525-17 Fuse holder
- 525-18 Volume control, 100K ohms
- 525-19 Bias resistor, 150 ohms, 10 watt
- 525-20 Bias condenser, 200 mfd. 50 volt
- *525-29 Brake assembly, complete
- 525-22 Suppressor coil
- * 525-27 Silicon diode, (2 used)
- * 525-28 Resistor, 100 ohm, 3 watt
- †525-25 Brake assembly, complete
- 525-20 Condenser, 200 mfd, 50 volt
- 525-22 Suppressor coil
- † 525-23 Resistor, 3 ohm, 10 watt
- † 525-24 Silicon diode,

*Indicates parts used in:

22H cabinets with serial numbers above 22750

22R cabinets with serial numbers above 40900

†Indicates parts used in:

22H cabinets with serial numbers below 22750

22R cabinets with serial numbers below 40900

508 Treble Horn-Pulley Assembly

- 508-1 Horn pulley moulding only
- 508-2 Horn reflectors (2 used)
- 501-6 Cotton filter
- 502-3 Felt oil reservoir pad
- 502-4 Oilite bearing insert
- 508-4 Bearing housing

509 Spindle Assembly

- 502-5 Metal thrust washer
- 502-6 Rubber thrust washer, 1-1/16" hole
- 502-7 Spindle and mounting plate
- 502-8 Rubber spacing washer 5/8" hole
- 502-9 Spacer, spindle mounting (3 used)
- 502-10 Rubber grommet (3 used)

203 Treble Speaker Unit

- 203-1 Fibre spacer ring

104 Treble Rotor Belt**507 Treble Rotor Idler Pulley Assembly**

- 507-2 Pulley wheel
- 507-3 Spring
- 507-4 Metal bushing
- 510-3 Rubber grommet
- 506-2 Wing nut

505 Three Step Motor Pulley (Upper)**506 Motor Assembly, Less Pulley**

(Same assembly, upper and lower)

- 506-2 Wing nut (2 used)
- 506-3 Metal shoulder bushing (2 used)
- 506-4 Rubber grommet (2 used)
- 506-5 Bracket (2 used)
- 506-6 Pulley support wire ring
- 506-7 Motor only
- 506-8 Oiling tube

523 PM Bass Speaker

NOTE: Replacement cones, not available. Factory installed only.

516 Single Groove Motor Pulley (Lower)**117 Bass Rotor Belt****510 Bass Rotor Support Assembly, Upper**

- 510-2 Bearing clamp, upper half
- 510-3 Bearing grommet
- 510-4 Ball bearing
- 510-5 Bearing clamp, lower half
- 510-6 Metal bushing (2 used)
- 510-7 Crossbar support
- 506-4 Rubber Grommet (2 used)

513 Bass Rotor

(With grommets, less cover)

- 513-2 Rubber grommet (ends, 2 used)
- 513-3 Rubber grommet (center)
- 513-4 Metal washer

517 Bass Rotor Shaft and Pulley**515 Bass Rotor Cloth Cover****511 Bass Rotor Support Assembly, Lower**

- 510-2 Bearing clamp, upper half
- 510-3 Bearing grommet
- 510-4 Ball bearing
- 510-5 Bearing clamp, lower half
- 510-6 Metal bushing (2 used)
- 506-4 Rubber grommet (2 used)
- 511-2 Lower support mounting plate

512 Adjustable Mounting Plate, Lower Motor**528 Dividing Network, Complete**

MISCELLANEOUS PARTS

- 526-10 Plastic oil tube, upper
526-46 Plastic oil tube, lower
526-19 Cabinet back cover, upper
526-21 Cabinet back cover, lower
525-8 Amplifier hold-down clip
530 Lubricating oil, in container

PARTS USED IN 22R ONLY

- 722-2 Speaker cover box
731-4 Angle bracket, speaker cover box retainer
731-5 Bracket, for mounting bolt

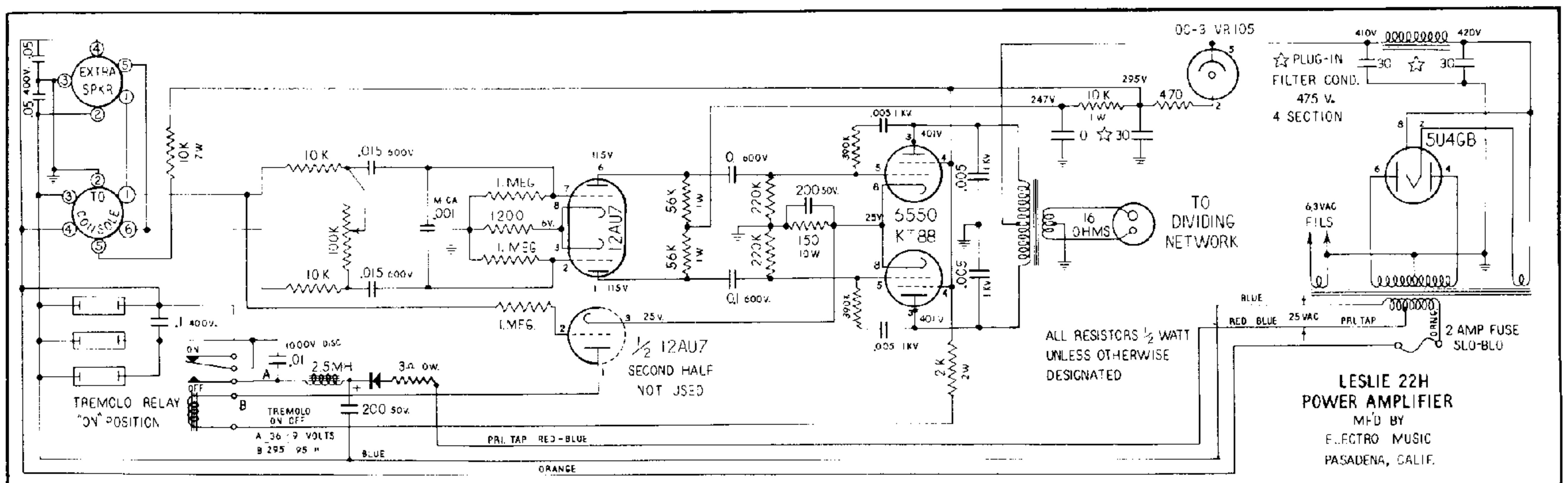
Note: The 22R speaker includes a kit of parts needed for installing the reverberation unit.

However, the reverberation unit kit (spinnet series with console-type speaker) should be obtained from the Hammond Organ Company.

MISCELLANEOUS SCREWS

<i>Thread & Length</i>	<i>Quantity and where used</i>
6/32 x 3/8" RHS self-tap	(2) Hold bottom cover on plastic control case
10/24 x 1 1/2" (black)	(12) Fasten backs to cabinet
#10 x 7/8" sheet metal	(2) Fasten motor mounting plate to wood shelf
10/24 "T" nuts	Used throughout cabinet
#8 x 3/8" sheet metal	Parts assembly
10/24 x 2 3/4"	(2) Fasten dividing network to shelf
10/24 x 1 3/8"	(3) Motor mount
10/24 x 7 1/2"	(1) For angle bracket, speaker cover box retainer, 22R only

Amplifier Schematic for 22H Cabinets below Serial 22750, 22R Cabinets below 40900









LESLIE ORGAN SPEAKER MODEL 22H AND 22R

"Pipe Voice of the Electric Organ"

GENERAL INSTRUCTIONS

Volume Control Setting

Organ signal output level varies from console to console, so the Leslie amplifier has a volume control to allow for correction

One Year Intervals

In addition to the rotor should be oiled at